Reuse of knowledge containers: a "local semantics" approach

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Abstract. In this paper we present two ways of considering reuse of systems of terms as knowledge containers. The rigorous approach is concerned with strict organization of terms and inferences, while the lazy one is based on terms used in various different contexts, without strictly predefined semantics. We argue that it is necessary to handle both advantages of such approaches in a median one, and present the AI-Strata model for description and use of audiovisual documents. This model has interesting properties that could help use and reuse term systems in different tasks and contexts.

1 Introduction

The general question of reuse could be summarized by: "To what extent can I reuse — in my context — what has been previously done (by me or others)— in other contexts — to make my current task easier?". This sentence can be applied to any object seen as a "knowledge container".

The purpose of this article is to present an original way of considering reuse of *systems (or organizations) of terms* like indexes, thesaurii, terminologies, or ontologies of concepts[1].

These kinds of knowledge containers are being set up for special uses into dedicated applications, designed for predefined tasks and contexts. The general reuse question we have to face is: how to reuse such term organizations in different applications, for tasks that are different from the initial one?

This paper is intended to present some ideas about two main ways of considering knowledge containers and use/reuse of them, mainly at the human/machine interpretation level, that we call the *rigorous* and the *lazy* one. After a short description of these two opposite approaches, we develop on what should be, according to us, "ideal" reuse, and present the AI-Strata model we have designed for describing and using audiovisual documents. This model has interesting properties that could tackle the "ideal" reuse we propose.

[1] All these categories could be thought of as different kinds of ontologies. We choose to restrict the meaning of this term to formal ontology of concepts.

2 Two main ways of reuse for systems of terms as knowledge containers

2.1 The rigorous approach

We call *rigorous* the first approach, as the kind of knowledge containers it entails is developed so as to be used in a context of tasks that are rigorously defined.

For instance, ontologies are set up for expressing the formalization of a conceptualization. The tasks sustaining their use are completely and precisely known, as the system has been organized regarding the inferences that must be carried upon them. Designing such systems is a long and difficult task, necessitating great investments in time and people.

In such systems, the interpretation of the terms (the concepts) must be strictly fixed, so that both men and machines can assign truth values to them, in an automated way. The linguistic interpretation of the terms naming the concepts must therefore be controlled, so that humans are able to understand what the machines did compute.

The first level of reuse that can be spotted in such rigorous knowledge containers is concerned with shared uses. Different users have to be able to use the system, i.e. understand the terms as concepts and the results of the inferences not only in a way similar with the one intended by its designer, but also in the same, collective shared way.

The contexts of use of such systems can be shared because they have been conceptualized precisely and are strictly related to the system of terms. The knowledge container defines the tasks for which it has to be used, and ensures that users fit into these contexts of use.

The second level of reuse deals with the reuse of the knowledge container itself to execute tasks that were not taken into account at design time. In the general case, this entails a careful extension of the system of terms around what had already been set up. Such extensions are very difficult to carry, as is also the simple maintenance of the system. KADS [7] proposes reusable components in different applications. [6] introduce in their system a way to consider reuse at its very conception. In the rigorous approach, even if conceptual contexts (for guiding reuse) are explicitly taken into account during the design phase, there is no way to extend them at exploitation time.

2.2 The "lazy" approach

Contrary to the rigorous approach, the *lazy* one deals with the design of organizations of terms in the contexts of tasks that are not, and cannot be precisely defined, for instance because they are very general (e.g. "search information").

The main objective is to collect and organize terms that contribute to describe an application domain, so that:

– they are used rather than others not belonging to the knowledge container;

– their inter-relations — *a minima* their common belonging to the same container, *a maxima* "conceptual relations" — help explaining how they should be interpreted. As a matter of a fact, no rigid organization of the terms is necessary.

Of course, anybody can use such systems, if they know the whole vocabulary, and reuse is mainly concerned with using the vocabulary without user's guidance. Any change in the context of use — be it the user and/or the task — defines a new way to interpret the terms in the vocabulary. The notion of truth does not really belong to such systems, as the computer only ensures that terms are used, that belong to the container. Interpretation cannot be frozen in the lazy approach, and should be let to the user. Of course, knowing in which context of use the vocabulary has been used should be a guide to its interpretation.

Possibly, new exploitation of the container can be guided by the traces of successful previous exploitations. The experience of previous use of the vocabulary can explain, if the contexts of use and the tasks are equivalent, how it is possible to reuse it in the same way.

As examples of systems of terms belonging to the lazy approach, keywords, thesaurii are to be found. For instance, keywords are used to index documents. If a documentalist uses a keyword in the context of one type of document or in one another context, the way to interpret it could change. Consider for example the keyword "funny" used to index a personnal webpage and a government website.

3 What should ideal reuse be?

We consider in this section what should ideal reuse of the terms organized in a knowledge container be.

Ideally, the terms should be used in various contexts, so that effective reuse takes place, with different users in the same context, but also in different contexts. Additionnaly, the possibility of setting up knowledge that had not been foreseen, mainly as relations that were not primarily described in the container (such as roles) should be given.

In short, the ideal approach for using and reusing a system of terms should :

– relax the constraint of universality of the rigorous approach: semantics eventually belongs to users, and possibly to computers;
– allow an interpretation that can be more or less constrained by contexts of use;
– as a consequence, allow control of the contexts of use, so as to be able to define particular semantics for particular tasks, and compare them.

Expressivity should be maximal, with existing means to control what should be expressed and understood. The next section of this paper is devoted to the presentation of an annotation model for audiovisual documents that meet our ideality conditions.

4 A model for audiovisual document description

The model we present here has been designed in the framework of the SESAME project. SESAME means *Système d'Exploration de Séquences Audiovisuelles et Multimédia Enrichi par l'Expérience*: experience enriched audiovisual sequences exploration, and is partially funded by France Télécom. One of the purposes of the project was to study how the use of an audiovisual information system (AVIS) could be enriched with experience of previous sessions.

The first step we proposed was the design of a model called AI-Strata sufficiently general as to be able to express any other AV description model. This model is primarely based on "semantic network modelling" as networks of so-called annotation elements are used to describe AV content. Annotation elements (AE) are *a minima* terms (which are described in a knowledge container), and annotation graphs can be thought of as term networks.

The second step of the study focused on interpretation and contextual exploitation of these networks, based on potential graphs, that are tools representing one particular way to search and contextualize terms in the network. We also proposed *description schemes* as means to control how the description should be "written" by the annotator, so how it should be "read" by other users.

We elaborate on these concepts in the next part. The interested reader should refer to [4, 5, 2].

4.1 An annotation graph

The main interest in AV document modelling is that it consists in modelling something that is usually described at very low level of conceptualization: mainly the superposition of audio and video streams. Every use of AV document going beyond simple visualization needs to ground on further modelling [1].

Describing and modelling a temporal medium is based on *annotation*, that means attaching a description to a temporally (on a temporal base) situated piece of document. The AI-Strata model is a very general one, based on the notion of annotation element. Annotation elements are objects, named with a term (e.g. Mandela, Shot or ZoomIn). They possibly have attributes (e.g. Speech:text, TimeOfDay:date), for more precision, or taking into account pre-calculated image features such as color histograms. Here, we will focus on annotation elements names, as terms.

Annotation elements annotate *audiovisual units* (AVU), that are defined with an audiovisual stream and two timestamps, defining strata (that may overlap) in the stream. As many annotation elements as necessary can annotate an audiovisual unit (see examples on figure 1).

So as to structurate the annotation, and get more expressivity than simple "keyword on the temporal stream", it is possible to set up relations between annotation elements. So as to get homogeneity in the description, we use only one relation type — the *elementary relation* R_e — that can be used to link any two annotation elements. Expressing the semantics of a relation is allowed through the use of one more annotation element, like in $Shot \rightarrow VideoFocus \rightarrow Mandela$ or $Mandela \rightarrow Agt \rightarrow ShakingHands$.

The model is called these elementary relations which property is to connect audiovisual units, i.e. AV document strata: annotation interconnected strata, AI-Strata.

Considering the expressivity and the generality of the model, the description it allows can be very rich, and there are of course a lot of possible uses. We actually want to ground every task in an AVIS upon that model.

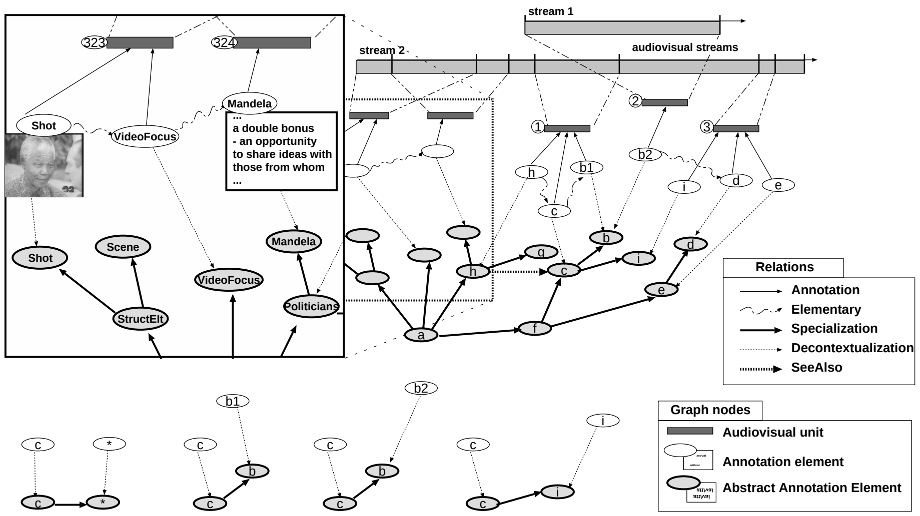

Fig. 1. Top: an AI-Strata graph G_g with annotation elements as terms extracted from a knowledge container. Bottom: a potential graph g_p and its three instances in the general graph G_g: g_{i1}, g_{i2} and g_{i3}

4.2 A controlled vocabulary as knowledge container

We consider that annotation elements have to be defined in a knowledge container, and cannot be created at will. We define our knowledge container as a network of *abstract annotation elements*. These elements are at least organized in a specialization hierarchy (not related to inheritance), and other conceptual relations are allowed. The knowledge container is at least a thesaurus, describing the terms (possibly their attributes) that could be used to annotate the stream. *A maxima*, the container could be considered as an ontology, defining with precise relations what concepts are defined, and could be used to annotate.

Abstract annotation elements (AAE) are clustered into *analysis dimensions* that represent containers that are actually used to annotate the stream. For instance, the stream could be analysed along $< DA : Politician >= \{AAE :$

$Clinton, AAE : Mandela, AAE : Chirac\}$ which is dedicated to politician annotation. Analysis dimensions are more or less "naturally defined in the container". For instance, if the abstract annotation elements $AAE : Clinton$, $AAE : Mandela$ and $AAE : Chirac$ are specializations of $AAE : Politicians$, the analysis dimension is naturally defined in the container. On the contrary, the analysis dimension $< DA : Celebrities >= \{Mandela, LaraCroft\}$ could not be so natural.

4.3 Contextual exploitation as contextual inferences

The audiovisual units, the annotation elements and the abstract annotation elements represent three types of nodes in a general AI-Strata graph.

The idea that was at the origin of the model was to consider that if an audiovisual unit u_1 was at first annotated by its own annotation elements, it was also annotated by annotation elements annotating audiovisual units u_i belonguing to its context. This context can be temporal (e.g. inclusion), but also conceptual, if there exists a path between two elements of the annotation graph. On figure 1, the AVU 323 is also contextually annotated by $AE : Mandela$ because of the path between AVUs 323 and 324.

By extension, the general notion of *contextual inferencing* consists in putting elements of the graph in the context of others (that are known, e.g. AVU 328), and/or to recognize elements as being in the context of others.

A context can be defined as a *potential graph*, which is an AI-Strata graph with generic nodes. A potential graph is instantiated in the general graph, so as to find subgraphs that are isomorphic to it (considering the generic nodes) [3]. Figure 1 gives example of a potential graph and three instances.

As a matter of fact, any exploitation task of the graph can always be thought of as potential graph creation, manipulation and instanciation. Indeed, queries consist in searching elements that belong to the context of known elements (for instance abstract annotation elements, unique by definition, or audiovisual units).

The interpretation of an annotation element (considered as a term) always occurs in the context of the AV stream, and mainly of other annotation elements belonging to the annotation graph. An annotation element is always considered as contextually enlightened with other elements defined by potential graphs.

4.4 Controlling annotation: description schemes

As said earlier, we need a means to control the annotation, i.e. to specify which annotation elements should be used, and how they should be linked together with elementary relations. Analysis dimensions allow us to define clusters of abstract annotation elements that should be used one for another ("paradigmatic" classes).

We define *description schemes* as networks (with extended elementary relations and temporal relations) of analysis dimensions expressing how abstract annotation elements extracted from analysis dimensions should be put into relation ("syntagmatic" relations between paradigmatic classes, as in linguistics analysis). An example of a description scheme is given figure 2.

Using a description scheme to annotate means that the use of the annotation vocabulary is monitored. This allows the definition of contextual inferences, that are related to general or more specific tasks, and contributes to transforming the lazy approach into a rigorous one. For instance, on figure 2 an annotation graph based on the description scheme *ds1* allows inferencing on the "Agent" relation.

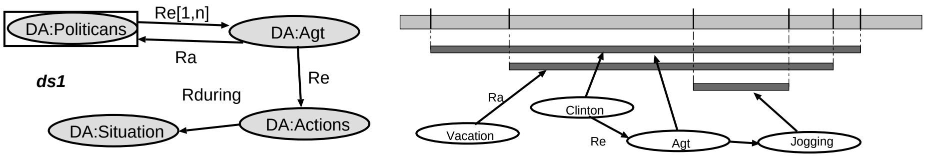

Fig. 2. A description scheme specifying that a "politician" (i.e. an annotation element created with an abstract annotation element extracted from $< DA : Politicians >= \{AAE : Clinton, AAE : Mandela, AAE : Chirac\}$) should be created, and annotate a new audiovisual unit (the box is a notational convention for it). The scheme also specifies that this annotation element should be put into relation with at least one other annotation element, defined in $< DA : Actions >= \{AAE : Speaking, AAE : ShakingHands, AAE : Jogging\}$, using $AE : Agt$ (uniquely defined by $< DA : Agt >= \{AAE : Agt\}$) as intermediate annotation element. Additionnaly, it is specified that the audiovisual unit created should occur during an audiovisual unit annotated along $< DA : Situation >= \{AAE : Vacation, AAE : OfficialReception, AAE : Inauguration\}$. AI-Strata relations as R_e : elementary relation, R_a : annotation relation or R_{during} : temporal relation complete the description scheme.

4.5 Considering reuse in AI-Strata

Finally, it appears to us that the AI-Strata approach correponds to the "ideal" approach we defined earlier. Terms interpretation is always based on contextualization of the abstract annotation element in the context of the knowledge base, or of the annotation element at the annotation level. Intepretation can be more or less constrained by the knowledge of the description schemes that have been used, that suggest possible contextualizations. Sharing description schemes between users is a means to favour reuse of terms, and "true" contextualization (in the sense of the annotator).

There is no universality in the knowledge container, while its organization can be as rigid as necessary, for instance if mandatory description schemes are designed. Reuse can for instance be considered at the description scheme level, while relations in the container remain valid in the general case, and new analysis dimensions, possibly not "naturaly defined" in it could suggest a new organization of the container. For instance, a new knowledge container could be extracted from another one, along the analysis dimensions that correspond to its actual use, in case these are not "naturaly defined".

Moreover, the local organization (i.e at the annotation level) of annotation elements-terms enlightens the reuse of abstract annotation elements (it is related to extracting description schemes from the real annotation).

5 Concluding discussion

As a conclusion to this short paper, we would like to suggest that reuse is mostly an effect of knowledge sharing between users, mainly on *how* to use terms defined in knowledge containers. We think that it is not mandatory for the organization of these systems of terms to strictly define how they should be used and interpreted. On the contrary, schemes like the description schemes are a way to get more control on the description. Analysis dimensions have also good properties as they do not necessarily rely for instance on a specialization relation in the container.

We argue that reuse needs plasticity: it must fit into different contexts, and the semantics of the vocabulary should not be strictly and globally defined. A local definition of semantics (annotation level) seems to us necessary, as human read and interpret terms in their own ways. The notion of "local ontology of concepts" could be defined, in which strict inferences and conceptualized tasks could occur (this leads to the notion of "local truth"), while at the global level, no global semantics occurs. The notion of semantic localization could be a way to allow the extraction of pertinent description schemes from real use of the system of terms, from which a new organization of this system could be set up.

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