Cases Base Memory Modelling for Medical Pictures Reuse

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Abstract: *The mass of multimedia data produced annually in hospitals are measured in terabytes; the need to manage this gigantic information mass becomes quickly extremely crucial. The actual management information systems of medical pictures present some limits like their capacities to answer the needs of the users. These limits are due to the fact that these systems don't take in consideration the semantic content of the pictures. Content research aims to pass this problem. One of the possible means consists in using description criteria of the picture semantic content for being able to reuse it. These criteria are known in the medical knowledge domain. We think that the use of an enterprise memory for managing this knowledge would be able to satisfy this need. We demonstrate our subjects by the realization of a prototype named "MECIM ".*

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1. Introduction

Since some years, the conception of a management system of pictures bases for medicine knows a big activity in research. The medical domain is among the domains of application where the number of pictures produced by the daily activity is very important.

Most actual solutions as Picture Archiving and Communication Systems (PACS) are interesting to the patient and consider the picture like a binary object. This restricts the interrogative possibilities, even while using the format standard DICOM, the content of the picture is only partially taken in account. However, a physician, in the exercise of his functions, is brought to look for cases of similar pictures. He takes for this multiple criteria, as the anomalies, the colours, the shapes, *etc.* in order to be able to establish a suitable diagnosis or before taking a therapeutic or surgical decision. Another aspect is also important for the physician: the evolution of the content of the pictures belonging to a same patient.

It is clear that all this is possible only if the content of the pictures is described, since the research itself is made through this description, and that some diagnoses are attached to the pictures. These descriptions and diagnoses are therefore a shape of capitalization of the physician's knowledge (experts of the domain). The management of this knowledge (picture and its content) requires a knowledge management system.

2. Enterprise Memory and Knowledge Management

2.1. Definition of the Knowledge Management

The knowledge management has for goal to keep, to transmit and to develop the knowledge. It is a real valorisation process of the knowledge involving all the organization actors; this is to facilitate the decision making. This process is decomposing in different creation stages, enrichment, capitalization, validation and knowledge diffusion. The knowledge management is a means to reach the concrete objectives having a direct tie with the activity of the enterprise. The capitalization of the enterprise knowledge is made through the enterprise memory concept.

2.2. Definition of the Enterprise Memory

Various definitions have been given by various authors. Pomian [17] defines the enterprise memory as the experience and the knowledge acquired by the enterprise. The enterprise memory approach represents the gait that aims to identify, to collect and to make exploitable this knowledge through an adapted support. The concept of enterprise memory regroups the gait and the enterprise memory itself. It adds that the enterprise memory is used by all functions of the enterprise. The decision-makers use some indicators to value the capital knowledge of their enterprise; the persons responsible of the human resources explore the profiles knowledge of the employees to manage better their politics of mobility.

According to [19], an enterprise memory is especially interested in the knowledge coming from the experience of the enterprise. It represents one of the means allowing it to manage a part of its knowledge. By definition, it results from the union of

the knowledge set acquired by the different persons of the enterprise.

2.3. The Methods and the Models of Enterprise Memory Construction

We can divide these methods in two distinct generations: a first generation of methods which objective is to construct knowledge base systems like expert systems (KADS, KOD, MACAO,) and a second generation of methods that interest us more, and which objective is to construct systems of knowledge capitalization with interesting to the whole organization knowledge (MUSIC, REX, DECIDES, MKSM, MARET, DOLMEN, RECARO,).

These methods manipulate the concepts of enterprise memory [17], heritage knowledge or enterprise knowledge system [11] [2].

The terminology System of ability Management is also proposed [13]. The KADS, KOD, REX, DECIDES, DOLMEN, MERX, and RECARO methods that seem to suit the realization of our enterprise memory are documented extensively in [6, 7, 4, 9, 18, 17, 10, 9, 15, 3, 2, 19, 1]

Within the framework of medical pictures management, the knowledge (pictures and their environment) are stored as cases to be reused according to needs expressed by the physicians (experts of the domain). It is for it that the RECARO method especially interests us since it is based on the notion of knowledge reuse, represented by cases.

3. RECARO Meta Model and Methodology

3.1. Definitions and General Concepts Proposed

Five notions on which articulate the enterprise memory modelling are defined: the reusable resource concept, the role concept, the case concept, the case network concept, and the context concept.

A. Reusable Resource Notion

We consider a reusable resource all immaterial or material object having been conceived for a specific use and able to be reused or having been reused already in different contexts. Every use of the reusable resource is characterized by its own reuse context (describes the manner with which the reusable resource has been used in a specific case).

B. Role Notion or Knowledge Element

According to [14], "the role qualifies the use that an activity makes with knowledge." The objective assigned to a role is the link of a use of a reusable resource to its reuse context. Every role has therefore for objective to describe a particular element of the context and to bind this element to the reusable resource. A role is therefore carrier of a semantic that is often given by the name of the role and possibly of the values.

C. CASE Notion

A case represents the description of use or the reuse of a reusable resource in a given context. A case is defined by a reusable resource, to which it has been decided to assign a set of roles. Every role is carrier of a unique semantic that is relative to the part of the context described.

D. CASES Network Notion

A cases network represents the description of coordinated use of several cases for the realization of a common and unique objective. A cases network represents an assembly of several cases therefore. The cases are collected by the slant of roles.

E. Context Notion

The context is a description of the situation in which the case has been achieved. The context can be considered following two aspects:

- The global description of the context: it is about describing in almost-natural manner the situation in which the case has been constructed;
- The description of the context parameters: it is about describing an organized manner every parameter which has been taken in account when constructing the case.

3.2. The RECARO Model

Its principle is inspired by the realities of reuse of concepts already used. Its objective is to put at the disposal of the users, models allowing them to describe their knowledge like a set of reusable resources and their use cases. The proposed memory is composed therefore by a set of reusable resources, a set of roles and a set of cases.

The problem resides in that, the models can be completely different from a domain to another. We don't describe a picture type resource with the same model which describes a portion of text type resource. The gait used offer therefore to the users, tools allowing them to conceive their own models respecting, of course, the transverse levels that we describe below. The proposed tools are materialized as Meta models. The following table gives a general view of the solution composition.

A. The Vertical Point of View

The vertical level describes the basic architecture of the enterprise memory. We recover the main components that are the reusable resources, the roles, the cases and the contexts.

- Reusable resource which forms the core of the enterprise memory. The set of the reusable

resources is considered as the capital knowledge of the enterprise.
- Role which is used like means of uses description of the reusable resources in different contexts.
- Case which is used to represent a particular use of a reusable resource.
- Cases network to represent the complex scenarios using several reusable resources.
- Context to describe the implementation of different uses of the reusable resources.

Table 1. The solution composition.

	Meta Level	Model Level	Process Level
Ressource	Resource Méta-Model	Resources Models	Set of Resources
Role	Role Meta-Model	Roles Models	Set of Roles
Case	Case Meta-Model	Case Models	Set of Cases
Cases Network	Cases Network Meta-Model	Cases Networks Models	Set of Cases Networks
Context	Context Meta-Model	Contexts Models	Set of Contexts

B. The Transverse Point of View

The used general model is described through three levels of abstraction for the modelling of the enterprise memories.
The five concepts, seen in the precedent point of view, are expanded following three levels:

- The Meta-models level which, is really provided by the gait. This level is constituted of a set of models permitting the construction of models of the five concepts.
- The models level which represents the set of the models constructed by the meta-models. These models constitute the architecture of the enterprise memory that we called the models memory.
- The knowledge level which represents the enterprise memory. It is constituted of: (1) the reusable resources memory: constituted of the set of the recorded reusable resources. (2) the roles memory: constituted of the set of the constructed roles. (3) the cases memory: constituted of the set of the constructed cases. (4) the cases networks memory. (5) the contexts memory: constituted of the set of the described contexts.

3.3. General Description of The Model

To make the RECARO model operational, it is necessary to make the Meta model level operational. The models and resources levels are deducted of the Meta model level and are bound to the problematic treated by the memory. In the following paragraphs, we are going to describe the five Meta models which constitute the general Meta model of the gait.

A. The Reusable Resource Meta Model

The reusable resource constitutes the core of the enterprise memory. It represents the central object on which carries the research in the memory. Every research consists in localizing a reusable resource that answers best to its needs, or more concretely to a set of fixed criteria.

These resources are different from each other, in their description and in their use. These resources are organized naturally in resources classes. Every resources class is described by its own structure. Besides, from a system (enterprise memory) to another one, the number and the type of a class are different. This diversity brings us to adopt leading principles for the construction of the Meta model. These principles are the next one:

- The reusable resources are hierarchized naturally in classes of resources, every class being characterized by its own structure;
- The number and the type of resources classes vary from a domain to the other;

In the enterprise memory, a reusable resource is seen like a set of features described by the user himself. In this Meta model, every reusable resource model is described by a set of properties regrouped in classes. Every property is, itself, described by a wording, a domain and one or several constraints.

B. *Properties Class*

It represents a set of gathered features in a family or a group, according to logical criteria of grouping. The properties class can be, itself, inserted in a super class or to gather some subclasses. For a same model, the designer can define a group of properties, said of a structure, that describe the structure of the reusable resource or environment properties that describe the environment of the reusable resource *etc*.

C. Property

It represents the description and/or the assessment of a particular facet of the structure of the reusable resource. Every property is represented by its wording, its type or its domain, as well as by a set of constraints on the domain. We recover systematically, on every reusable resource model, the property describing the code of the reusable resource and the one describing its wording.
The notion of constraint is interesting, since it permits, for example, to determine if the property is public or private, or if its value is obligatory or no.

D. The Role Meta Model

As described previously, the roles are the main mechanisms used to qualify, describe and comment the use of a reusable resource in a given context.

Every use of a reusable resource is described as a case, with the use of a set of roles.

In the structural point of view, a role is seen like being a system characterized by a set of properties and in relation with one or several reusable resources.

E. The Context Meta Model

We have defined the context as being the description of the situation in which the case has been achieved. The context Meta model is used to construct different contexts models. It assumes that a context is characterized by a wording and is composed of a set of properties. The notion of context model is interesting, since it permits to create a memory of contexts composed of a part of contexts models and a part of contexts. This memory of contexts permits a better management of these contexts and open perspectives of more interesting research by the contexts.

The context notion can be considered like complementary for the description of the cases and takes in charge the description of the portions of contexts not formalised and not described therefore by the roles.

F. The Case Meta Model

The case represents the description of the use of a resource in a particular context. The research of a case consists in localizing a reusable resource already used in a specific manner. In the same order of ideas, the description case meta-model is provided like a tool for the generation of the case description models. It is also a network of concepts describing and normalizing the components and the rules necessary to the construction of case models.

The case Meta model permits to generate all case models necessary to well working of the memory enterprise. It answers to the same constraints of the reusable resources description meta-model. The case Meta model justifies itself for predefined cases. A lot of situations exist, that we will qualify as normal, that describe scenarios of use of resources defined by the constructor. These scenarios are often described by technical cards. We can consider modelling every scenario taking the form of a case.

G. The Cases Network Meta Model

We have defined the cases network like representative the description of coordinated use of several cases, for the realization of a common and unique objective. It is constituted of an assembly of several cases by the slant of roles. This Meta model permits to construct the models permitting, themselves, to describe scenarios of coordinated use of several cases.

H. Conclusion on the Model

With regard to the gait, although it is not formalized here clearly, it imposes itself in a natural manner, since it is guided by the Meta model. The implementation of the meta-model is considered like being the gait to follow to construct the enterprise memory. This gait recommends to:

- Construct the models memory: marking and counting the five concepts defined by the Meta model, organizing them in groups capable to constitute some families, so that every family can be represented by a model. We already know that the model memory is constituted of the usable resources models memory, of the roles models memory, of the case and cases network models memory and of the contexts memory;
- Construct the enterprise memory: putting in place the five memories of the knowledge level.

4. System Modelling

We are going to experiment the model described previously in the context of the medical pictures management. The modelling consists in putting an enterprise memory in place. The knowledge capitalized in this memory is those of the medical imagery experts (physicians and radiologists) and concern the description of the pictures and the development of their diagnoses for a better management and reuse of these pictures.

We describe this memory through its components as they are generated from the Meta model. We start therefore with counting these concepts:

- The reusable resources: picture, description, result, text and physician.
- The roles are classified in three categories: intern, link and mediator.
- The networks cases can only be counted by the physicians; we leave them the liberty to construct them from the reusable resources and roles.
- For the context, since it is a complementary and useless concept in our model, it won't appear here.

The modelling of the memory should permit to reach a certain number of objectives. For help to the diagnosis, the system should allow the physician to be inspired by similar cases to establish a suitable diagnosis. For the patients follow-up, it should allow the physician to follow the evolution of the pictures belonging to a same patient; concerning the teaching, the system should help to the formation of the medical students with presenting them sets of similar pictures according to different criteria, accompanied by their descriptions and diagnoses. The system should offer to the researchers the possibility to do pointed research, in the picture base, thanks to the multiple precise criteria that label the picture.

4.1. Modelling the Reusable Resources Memory

The Reusable Resources Description Models (RRDM) is generated from the Meta model of reusable resources description. A RRDM is generated to describe a set of reusable resources of a same type or of a same family. Following the requirements of the Meta model, the properties of the reusable resources are regrouped in similar properties groups. Every properties group includes similar properties following a given criteria. In the enterprise, we can find several types of different reusable resources but used in a same domain. This heterogeneity of the reusable resource types, bring us to construct several reusable resource models, every model describing a type of reusable resource. With the assistance of the physician radiologists, we counted five reusable resources: PICTURE, DESCRIPTION, TEXT, RESULT and PHYSICIAN.

These concepts are autonomous entities to which we can apply the reusable resource model (they have some properties), that we can label (by roles), that interact (bounded by roles) in different situations (cases).

4.2. Roles Modelling

A role qualifies the use made of a reusable resource. It is carrier of a semantics that is often given by the name of the role and possibly of the values. We can classify the roles according to the reusable resources that they implement. We recover some roles that implement only one reusable resource. This resource is called current resource; its roles are called internal roles. Other roles implement two reusable resources, the current reusable resource and a second reusable resource that we call invoked resource. These roles generally invoke a link between a reusable resource and another one. We call them link roles.

The last type of roles is that implementing three reusable resources: the current resource and two other reusable resources. These roles show how the current resource can act as mediation between the two others. We call them mediation roles.

4.3. Cases Modelling

The cases description models are generated from the Meta model of cases description. Their objective is to act as mould for the representation of the reusable resources use cases. Every model describes a type of well determined case.

Since a case is defined like being the description of a particular use of a resource, the cases description model is bound intimately to the one of the reusable resource. The cases model is an extension of a reusable resource model. This extension makes itself by the labelling of the reusable resources model, by models of roles. In fact, a cases model must include a reusable resource model inevitably.

A same reusable resource can be used in different manners, in different situations and especially in different configurations. To a same reusable resource model, we can associate several models of cases therefore. Every cases model describes a particulaire use configuration.

4.4. The Cases Networks Modelling

In the reality, the reuse of the reusable resources is described through cases. However, the notion of case has a very intimate relation with the resource. The range of the case is limited to the reusable resource only. This limitation poses problems of descriptions of situations that pass the simple reuse of a reusable resource. There are, for example, some situations that take all their sense only after the description of the interaction of several use cases of several reusable resources.

It is necessary, therefore, to introduce the notion of case scenario, definite like being the description of the interaction of two or several cases for the realization of a common objective. Thus, a cases scenario can be seen like a cases network connected by roles. This definition allows us to use the concept of roles, already definite.

Figure 1. Result of a query.

4.5. System Realization

We have developed a prototype using the model described which offers two methods of research.

The recuperation occurs when the user searches for a specific case: I search for the cases containing the pictures of adult patients (age) presenting a tumour (pathology) to the brain (organ). It is expressed by a query. These are the experienced users who use this research mode.

The exploration occurs when the user doesn't have no idea on the searches he is going to do “I search for the diagnoses of a picture that interest me.” He starts with a resource and reaches the information with browsing the resources that are bound to him. These are the new users who use this research mode.

However, the user can combine the two methods of research:

- With browsing the gotten results using the first method (result of a query), Figure 1.
- With using the first method to launch a query after an exploration that allowed him to fix the criteria of research as shown in Figure 2.

Figure 2. Fixing the research criteria.

5. Conclusion

With the technological progress (multimedia, WEB, *etc.*), the integration of the pictures in the management systems of data bases become necessary in several domains. Indeed, thousands of pictures are produced daily by medical equipments, militaries, civilians, *etc.* the use of the pictures requires new methods of storage, organization, research and navigation. Since the years 70, the research of pictures knew an important activity of research and survey.

In this paper, we developed a system of reuse cases base pictures dedicated to the medical imagery domain. In this domain, the existing solutions are founded on limited parameters as the patient's name, the acquirement date of the picture, *etc*. However, the heterogeneity of the users (physicians, students, researchers, *etc*.) lead to very varied requirements that pass the capacities of the present solutions.

To answer to this problematic, we exposed a description model permitting to represent the picture through three facets that are: the context, the semantics and the graphic aspect of the picture; this is done with using the RECARO model (Resources, Case, Roles,) that permits the knowledge reuse.
We estimate therefore, that the modelling used in the domain of the medical imagery, is fruitful.

Indeed, after the phase of modelling, in which it was necessary to adjust our solution to adapt it to the RECARO model while respecting the objectives raised at the beginning. If this model didn't facilitate us the data updates, it has simplified us the research (by using the roles).

We developed a first prototype baptized MECIM and based on the description model proposed. It allows the physicians to enrich a cases base that they judge applicable for an ulterior reuse, where research makes itself in a simple, fast and efficient way, thanks to the two fashions of research that it offers: the scrolling and the recuperation that are made with expressing query based on different features, fixed by the physician.

Another strong point of the prototype developed is the flexibility since it offers the possibility to enrich the list of these features with the progression of its use according to the users needs.

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