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# Causal reasoning and symbolic relationships in Medieval Illuminations

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## Abstract

This work applies knowledge engineering's techniques to medieval illuminations. In this article, an illumination is considered as a graph of knowledge which was used by elites in the Middle Ages to represent themselves as a social group and to showcase the events in their lives. To do so, combination of symbolic elements were used to encode influential messages moreless implicitly. Our work aims to identify the meaning of these elements through a logical model using ontologies. The idea is to identify logical reasoning rules and to simulate them using artificial intelligence mechanisms. This, in order to facilitate the interpretation of illuminations and to provide a logical formalisation of new encoding and information transmission services in the future evolutions of current social media.

## Keywords

Symbolic relation; Medieval illumination; Semantic relation; Ontology; Social network

## I INTRODUCTION

Knowledge engineering aims to formalise human knowledge so that it can be manipulated by computerised systems. In this paper, its techniques are used to characterise and formalise symbolic relations (social norms) between concepts. Medieval illuminations are images which in the Middle Ages, were designed and used by elites to showcase events but also to represent themselves as a social group. Illuminations constitute an information system based on symbolic relations with meanings and messages that are determined in a particular and a changing context. They can be represented by knowledge graphs. The strong correlation between the medieval illuminations and the social media is firstly explained by the processes through which the illuminations served as a visual support for the social communication. Even if the power of images is to illustrate scenes, they also aim to act on the cognitive perceptions of users and therefore on their behavior. The medieval illuminations used in our work refer to those related to the court of Burgundy Duke (cf 2.1), Philippe The Good<sup>1</sup>. They were made for the Duke, with the goal to influence his social network: families, knights, allies, enemies, other European princes, competitors, etc. This influence was shown during the expositions, and was also reinforce by the copies of these illuminations that others persons made. These medieval illuminations could be considered as the first social media and can help to enrich the structure of current and future social media.

The main issue we faced during our study is the abundance of symbolic relations strewed in the medieval illuminations. To highlight the meaning of these relations, their components must be

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<sup>1</sup>Philippe The Good (1419-1467) is the most famous of Burgundy Dukes and one of the most powerful European princes at the Hundred Years War's time (1337-1453).

specified and formalised properly. Another problem we also faced is the strong correlation between these components, this leads to new knowledge which can be inferred from the explicitly made ones.

### **1.1 Research objectives**

We seek to identify the meaning of symbolic elements and semantic relations in medieval illuminations through a logical modeling using ontologies. Combinations of symbolic elements illustrated in the images, were used to encode influential messages moreless implicitly. To achieve this, we develop computerised tools and ontologies to capture and model the meaning of symbolic elements and their relations. Beyond a simple taxonomic modeling, we could constrain the illumination's ontology to make it more expressive. The level of expressiveness reached is equivalent to the SHOIN(D) language (cf 4.1) in description logics. This allowed us to build reasoning rules and to use a triplestore<sup>2</sup> inference engine. Then our computerised system could be able to reason on graph's elements that describe the illuminations and to discover new implicit knowledge.

The digitalisation of cultural heritage data is an active research field. It has been especially increase with the proliferation of digital museums on Internet. In our work the combination of these data, knowledge engineering's techniques and social networks is a main contribution for that digitalisation. The data we analyse, those of medieval illuminations, could be structured as knowledge graph like the structure of current social media. So, the comparison of the two structures could allow to enhance the current social media's one. The use of knowledge engineering's techniques on these data, through their representation, their storage, their easy interpretation, their combination with others data and their reuse by computerised system; is very helpful for the performance of professional in the cultural heritage.

### **1.2 Organisation of the document**

In the following sections, we will firstly present our vision on social media and show the correlation between illuminations and these social media. Then an historical context and principle of design of illuminations will be detailed, before the presentation of some backgrounds of our study. After a modeling through ontology of illumination with some examples of formalised symbolic relations will be showed. And we will present an interface of our prototype for the annotation of illuminations. Finally we will conclude and give some future work perspectives.

## **II SOCIAL NETWORK AND MEDIEVAL ILLUMINATIONS**

Social networks are the subject of many academics and industrials research projects. These projects deal with different aspects of social networks: social relations analysis [Raad, 2011], sentiment analysis on social networks [Martínez-Cámara et al., 2014], implicit communities discovery in social networks [Leprovost et al., 2012], profiles extraction in a social network [Ramiandrisoa and Mothe, 2017], information's dissemination on social networks [Bakshy et al., 2012], etc.

All of these studies required a large and diversified set of information in different contexts where the notion of social network refers to any relationship involving regular social interactions between individuals, organisations, companies, regions, countries, etc. These relationships are

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<sup>2</sup>A triplestore is a database especially designed for storing and retrieving RDF data (Resource Description Framework, a knowledge representation format in the form of a triplet (subject, predicate, object)). Like a relational database, it stores data and retrieves them through a query language

based on acquaintances, collaboration, collegiality, friendship and others. They can be direct relationships (an entity  $A$  has a direct relationship with the entity  $B$ ,  $A \rightarrow B$ ) or indirect ( $A \rightarrow B \rightarrow \dots \rightarrow X$ , so  $A \rightarrow X$ ); symmetric relationships ( $A \rightarrow B$  implies  $B \rightarrow A$ ) or asymmetric relationships ( $A \rightarrow B$  does not involve  $B \rightarrow A$ ).

Every social network is maintained by the sharing of resources which can be material (money, livestock, food, equipment, weapons) or not (information, strategies, decisions, mood, activities). More the reactions of members on the shared resources are high in the network, more important it becomes. This sharing of resources is one of the fundamental characteristic of a social network, represented by a virtual community: website on the internet (Facebook<sup>3</sup>, LinkedIn<sup>4</sup>, Viadeo<sup>5</sup>, Twitter<sup>6</sup>, etc.) or real life community. In the case of virtual community it is called **social media**.

To sum up, a social media is a set of representations (avatars) of individuals or moral people that contribute or not in a computerised platform by sharing messages or documents; and who are encouraged to interact each with others publicly or in private using the disseminated information. The majority of the current social media are structured around the valuation of the "me" of individual users through their avatars.

## 2.1 Illumination: definition and principles of design

This representation of the "me" and "my" environment is known in the human history. Rock paintings illustrated a vision which was published through a horizontal support, writing and drawing (as opposite to oral dissemination, called vertical). In the Middle Ages, to communicate with the educated class in the society, the illuminations were developed in books. An illumination is a fixed painting, made on a manuscript parchment's sheets (usually tanned animal leather). It is a codified representation to value the "me" of the sponsor. This codification can easily be represented as a graph that describes semantic and symbolic relations between objects. That graph also express concepts and conveys explicit and implicit messages. It is structured using topology (positioning relations), hierarchy, semantic (for example meronymy) and metaphorical relations (for example, an animal representation to express a human moral value).

A metaphor is an important rhetorical process since antiquity. A medieval definition of metaphor comes from the *Greek metaphora and Latin translatio*, it literally means the replacement of the true significance of something by an imaginary term, responding to an implicit comparison [Pernot, 1993]. It is done using four methods: from the animate to the inanimate, from the inanimate to the inanimate, from the animate to the animate, from the inanimate to the animate. Metaphorical relations are very common in the illuminations we study: the illuminations of the Burgundy Duke's court.

The court of the Duke was an aristocratic micro-society, composed of a set of entities including the Duke himself, the Count (his eldest son), the ecclesiastics (bishop, clerics), the knights. Its territory was vast from the south of actual Burgundy to Amsterdam; partially made of rural areas, but also urban areas (Brussels, Bruges, Ghent, Dijon, Lille, etc.). Different social groups in the network of the court (bankers, shopkeepers, academics, townspeople, etc.) operated in moreless wide networks. The illumination in figure 1 illustrates a network composed of the

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<sup>3</sup>[www.facebook.com](http://www.facebook.com)

<sup>4</sup>[www.linkedin.com](http://www.linkedin.com)

<sup>5</sup>[www.viadeo.com](http://www.viadeo.com)

<sup>6</sup><https://twitter.com>

Duke, his son the Count, the Advisors and the Knights. Together they formed the closest social network symbolised by the Golden Fleece collar.

In illuminations, some objects, characters or images as a whole are also considered as a sign (sometimes stronger than metaphor or working through metaphor). An illumination is always made in artistic, religious or profane context. It is part of a communication channel from the sponsor (here, the Duke of Burgundy), the author (illuminator) or the copyist of the book to the target (the Duke, a noble of his court, a politician, a king / queen or an important figure in a European court). It represents themes corresponding to the sponsor / recipient, his social level, his cultural settings, his family; his society in the past, the present, the future (after death). Then it aims to give an ideological representation of the sponsor. Implicitly it serves to convey ideas; idealize relationships, chivalrous and religious values. Explicitly it illustrated scenes of life in the court such as banquets, weddings, balls, etc. The scenes it describes and their meanings are not unique, they change with the context. These scenes were selected by a writer (the illuminator, the person who paints the images) and drawn as images. These images served as information to be disseminated about the Duke and the activities in the court and to be published during political events such as the luxurious manuscripts donation to the Duke (scene described in the Duke illumination depicted by the figure 1), a banquet or a large knight's assembly.



Figure 1: Illumination presenting a scene of a manuscript donation to the Burgundy Duke. *Brussels, Royal Library of Belgium, ms. 9243, folio 185 verso, Chronicles of Hainaut by Jean Wauquelin, 1446*

## 2.2 Correspondence between illuminations and social media

From these virtues and uses, an illuminated book is a social media like Twitter or LinkedIn, in terms of communication and resource sharing tool. However an illumination in itself can be assimilated to an animation or upkeep resource of a social network (the Duke's social network) insofar as it tells and shares a history with the network members. Its goal is then to show the influence of the Duke and to convey it. Some signs of this influence could be seen through some relations in the illumination such as :

- the allegiance of the court to the Duke; the councilors, the illuminator, the Count, the knights (except for the green one), the greyhound are faithful to the Duke. In the same way, the councilors stand behind the Duke and the writer is kneeling face of the Duke;
- the wealth of the Duke, through the purses he wears and his outfit;
- the power of the Duke, he holds a command stick.



### III RELATED WORKS

In general, the use of ontologies for the representation of knowledge graphs is not new and several studies treated it. More specifically for social networks which are knowledge graph composed of entities linked by social ties, a famous ontology has been modeled: the FOAF<sup>7</sup> ontology. The authors designed this famous ontology after a deep analysis of social network platforms. They gathered and reviewed information from activities, events, documents (images, videos, etc.) that users post on these platforms. By understanding how the users were organised and how they interact each with others through the posts, the authors built the FOAF ontology which is used like dataset that represent social networks platforms. The FOAF's specification is detailed in [Brickley and Miller, 2007]. FOAF has been used by many authors who seeked to treat some issues in these platforms such as trust in recommendation systems [Golbeck et al., 2006], [Sherchan et al., 2013], security [Kruk, 2004], etc. These authors modified the FOAF ontology to include an initial trust scale in the relationship between entities. We used FOAF ontology to show the similarity between illuminations and the social media, to extend our illumination's ontology so that to be more exact in our specification.

About the description of medieval images and cultural heritage in general, [Dörr, 2002] proposes an ontology (CIDOC object-oriented Conceptual Reference Model, CRM) that models information on cultural heritage. It describes the concepts and relationships underlying the structures of the documents used in the domain of cultural heritage. According to the website<sup>8</sup> dedicated to CIDOC-CRM, it contains 90 concepts and more than 140 properties both organised in subsumption relation. The model provides the level of details and precision necessary for museum professionals to perform their work well. It is very common, because it covers every single document used in the field of cultural heritage and it has a high contribution in the digitalisation of this field's data. The ontology we propose here also contributes to the digitalisation of the cultural heritage's data but it is specific to the Burgundy Duke's illuminations. Many other works on historical images (museums, archives, etc.) use the CIDOC-CRM so that to extend their ontology through mapping.

The [Doerr et al., 2006] extended the CRM by combining it with another ontology that describes the digital library. This promoted knowledge integration. Our ontology also, can be extended to other models (FOAF, for example). The [Damova and Dannélls, 2011] proposed an infrastructure to allow the easy extension of the domain specific data, and convenient querying of multiple datasets. The approach is based on a model of schema level and an instance level alignment. This infrastructure combines several ontologies such as PROTON<sup>9</sup> and CIDOC-CRM. The resulting ontology is applied on real data from the Gothenburg City Museum so that to handle queries on multiple dataset in the way of open linked data (LOD). Our ontology could be used in the same way. We linked it to others ontologies, for example FOAF, the Event ontology<sup>10</sup> and it could be a dataset on illuminations of the Burgundy's Duke.

Information Extraction aims to retrieve certain types of information from natural language text by processing them automatically [Wimalasuriya and Dou, 2010]. For example, an information extraction system might retrieve information about art works made by an artist, from a database

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<sup>7</sup>FOAF, Friend of A Friend is a popular ontology that describes the social relations between entities as well as the interests of these entities in a social network

<sup>8</sup><http://www.cidoc-crm.org/get-last-official-release>

<sup>9</sup>PROTON is an upper-level ontology, 542 entity classes and 183 properties. <http://proton.semanticweb.org/>

<sup>10</sup><http://motools.sourceforge.net/event/event.html>. Event ontology is centered around the notion of event, seen here as the way by which cognitive agents classify arbitrary time/space regions.

while ignoring other types of information. Ontology-based information extraction has recently emerged as a subfield of information extraction. Here, ontologies play a crucial role in the information extraction process [Wimalasuriya and Dou, 2010]. The proliferation of resources sharing services on Internet increased the image retrieval from web pages or others repositories. A main goal in image retrieval is the finding of images based on their semantic content, for example their topic or contents (objects, persons, etc.). Currently there are two major image retrieval paradigms that attempt to provide this: text-based metadata image retrieval and content-based image retrieval (CBIR) [Manzoor et al., 2012]. According to the goal mentioned above, CBIR is the most used and it is based on ontologies for the easy description of image's contents and the calculation of their content based similarity. This similarity allow a user to find more exact and related results in images extraction process respective to the contents. CBIR approach is used in [Manzoor et al., 2012] so that to propose a system through which an end-user will find relevant images when he is faced with a repository of images whose content is complicated and partially unknown to him. To do this, the authors provide semantic annotation of all images stored in the repository, following an ontology built for that purpose. CBIR is also a trend in annotation of social media images like applied by [Ghosh and Bandyopadhyay, 2017] for the semantic annotation on social media images so that to facilitate their retrieval, semantically combination and reuse by computerised systems. The ontology we built could be used like support for images (illuminations) semantic annotation, so that to accurate illuminations retrieval from an illumination's repository according to their content.

Cultural heritage data are considered syntactically and semantically very heterogeneous, multi-languages, semantically very rich and highly connected because they are produced by different entities (museums, archives, archaeological digs, etc.). The [Hyvönen, 2012] gives an insight about when, why and how to use Semantic Web technologies in practice to publish cultural heritage knowledge on the Web. He mentioned most of the formalisms we used in our work. The main reasons that motivate us in this study are: the sharing of the knowledge extracted from illuminations, their interoperability and possible integration in other similar knowledge and the provision of a valid model which helps to develop computerised systems used in the management of cultural heritage's knowledge.

Moreover, the particularity of the ontology we built is in its frequent evolution. We can integrate concepts from others illuminations so that to build a great dataset about illuminations. The system that accompains the built ontology helps a lot in this integration process. The system actually allows the user to load an illumination and to extract its components, by manual delimitation through some features. That is the first step of building the ontology. The system must also allow the automatic integration of new concepts in the already built ontology from the new loaded illumination, if it does not contain them yet.

#### **IV SEMANTIC FORMALISATION OF ILLUMINATIONS**

This section is dedicated to our semantic formalisation of illuminations. A brief description of the concepts and used terms is given as well as some results we found.

##### **4.1 Ontological modeling of an illumination and the light on the terms and formalisms used**

Etymologically related to the theory of the existing, the term "ontology" has many definitions in the literature, because it is applicable to many fields such as philosophy, information sciences,

linguistics, knowledge engineering, artificial intelligence, etc. In our project, we used the definition in [Studer et al., 1998]: "An ontology is an explicit and formal specification of a shared conceptualisation".

An ontology represents a formal conceptualisation of a domain [Gruber, 1993]. Here, a domain refers to the environment we wish to describe. An ontology includes a hierarchical organisation of the relevant concepts in the domain, the relations that exist between these concepts as well as rules and axioms that constrain their operations. The knowledge of a domain is formalised in an ontology using five main components which are:

- concepts, also called classes, correspond to the relevant abstractions of the domain retained following the final objectives and applications of the ontology;
- relations definite relevant associations between concepts. These relations can be hierarchical (generalisation (Up-Down)/specialisation (Down-Up), aggregation/composition, instance of), associative, equivalent (synonym, homonym, antonym, etc.)
- axioms are assertions accepted as true about the domain abstractions. They constrain the operations of the concepts and allow to infer new knowledge from the described one in the domain;
- instances constitute the ontology extensional's definition. These objects convey the static or factual knowledge of the domain.

For the illumination of the figure 1, examples of ontological components are: the concepts (*Duke, Book, Greyhound, Knight, Activity, Person, Animal*); the generalisation relations (*Duke is a Person, Greyhound is an Animal*), aggregation (*a Project is composed of Activities*), synonymy (*Prince is synonymous with TheCount*), associative (*Writer offers the Book, the Book is offered to the Duke*); the instances (*banquet, game, hunting, falconry* are instances of activity). The ontological representation of a domain must banish any semantic ambiguity. That provides a support for an uniform knowledge for the user's community, a reusable knowledge base, knowledge for effective sharing and communication.

This constraint is ensured by the use of a formal language: the description logics (DL) in our work, through its variant SHOIN(D). This DL's variant is widely used in ontological representation because of its expressiveness, decidability and controlled complexity. The constructors (the set of lexical symbols and operators used in the DL) of DL give it a sufficient expressiveness for the ontological description. These constructors are S(ALC and R+), H, O, I, N [Baader et al., 2005], [Baader, 2011]. Their meaning are:

- **S(ALC and R+)**: is the name given to a DL's sub-variant which groups the ALC constructors (basic DL's sub-variant composed of following operations - the definition of the global concept (Top, represented by  $\top$ ), the concept of nothing (bottom,  $\perp$ ), every concept (*Duc* for example), the conjunction of concepts (*Duc AND Knight, Duc  $\sqcap$  Knight*), the universal quantification (All the Duke's children,  $\forall child.Duc$ ), the existential quantification (the Count's father,  $\exists father.TheCount$ ) and the negation of a concept (not Animal,  $\neg Animal$ ) and constructor R+ (which allows the composition of roles (relations). *Example: father(father(X, Y), Z) to say that X is the grandfather of Z where X, Y, Z are concepts and father, a relation*);
- **H**: designates the constructor of the hierarchy between concepts. *Example: Duc is-a Person, Duc  $\sqsubseteq$  Person*;



- **O**: designates the constructor of instances. *Example: games, banquet are activity instances,  $Activite\{games, banquet\}$ ;*
- **I**: is for the inverse of a role (a relation). *Example: the child relation is the inverse of father,  $child.\top \equiv \exists father^{-1}.\top$ ;*
- **N**: is for the number restriction. *Example: Knights are up to 8,  $KnightNumber.\leq 8Knight$ .*

Moreover, these constructors can be combined, by operators of hierarchy (subsumption, expressed by  $\sqsubseteq$ ) or of equivalence ( $\equiv$ ), to definite other concepts or to organise them through rules(or axioms).

The table 1 presents some ontological concepts, relations and individuals (instances) of the illumination depicted in the figure 1. Figure 2 represents a view of the concepts of an ontology on this illumination, modeled in Protege<sup>11</sup>.

Once this modeling is finished, it could be saved in a formal syntax's form in a language<sup>12</sup>, such as RDF/XML, Turtle or OWL, generated by the tool (Protege). Our ontology is extensible and it can be combined with others ontologies, to complete the initial modeling, such as FOAF with which it has many common terms like *foaf:Person, foaf:member, foaf:interest, foaf:Group, foaf:depict, foaf:Image*.

In addition, we have developed a web platform<sup>13</sup> that allows to select an illumination and to index semantically its components. On this platform accessible via a web browser, it is possible to load a digital version of an illuminated image (in jpeg or png format). Then graphic selection's tools are used to frame important elements in the image as concepts. Once these concepts are annotated, it is possible to define semantic relations between them. This allows to extend the ontology. The verification of the added relations and the definition of rules of inferences are not yet treated and will be the subject of future works.

Even if the annotation of the concepts and their relations are made manually, nevertheless it is done following a list of these concepts and relations provided by the medievalists (experts in medieval illuminations). This guarantees a certain coherence in the concepts and relations annotated. The figure 3 illustrates an interface of the platform. It shows us some annotations made and related in the illumination of the figure 1. Annotations and relations created can be retrieved and saved in JSON<sup>14</sup> format. This file is created to allows the extension of the ontology on both its Tbox (the set of concepts of an ontology and their relations) and on its Abox (the set of instances, facts or individuals in the model).

The construction of this ontology is realised from the expertise of medievalists. The built ontology can be queried by SPARQL<sup>15</sup> so that to extract targeted components and to answer clear questions such as *activities represented in the illumination; who are the faithful persons to the Duke; etc*. The interest of ontology is its ability to discover new knowledge from initial described ones. This discovery is achieved by the construction of inference's rules and their

<sup>11</sup>Protege is a software dedicated to ontology modeling. <http://protege.stanford.edu/>

<sup>12</sup>RDF/XML, Turtle are computer languages used in ontologies development. To respect the number of pages allowed, we have not developed the specification of these languages

<sup>13</sup>Illumination3.0, our platform (the implementation is in progress) for the annotation of medieval illuminations of the Burgundy Duke, Phillip The Good. <http://illumination.checksem.fr/#/login>

<sup>14</sup>JSON (JavaScript Object Notation) is a lightweight data exchange format. It is easy to read, write and analyse

<sup>15</sup>SPARQL is the language used to query an RDF database (or triplestore defined above). It is similar to the SQL language used to query relational databases

application within an inference engine. Beyond our terminological description of illuminations, the interpretation of some symbolic elements remains to be defined through the formulated inference rules. We are currently working on the construction of these rules in SWRL<sup>16</sup> (Semantic Web Rules Language) so that to reason about symbolic relations within an illumination. In the one depicted in the figure 1 some examples of symbolic relations and their formalisation with Horn clauses are in the table 2.

#### 4.2 Example of formalisation of symbolic relations: metaphors

The formulation of logical rules in the form of Horn's clause will enable us to interpret metaphors, common in illuminations. Metaphor is a rhetorical figure that makes a not explicit but intuitively perceptible comparison between two dissimilar concepts. Although the two concepts related by the comparison belong to different semantic fields, they all share a common characteristic that allows to make the analogy between them. For example, one can praise the bravery of a man by designating him by a lion but man and lion remain concepts that are totally different (man is a human while lion is an animal). Although there is no real consensus from linguists on a universal typology of metaphors [Perrenoud, 2002], two main types can be enumerated: metaphor in praesentia and metaphor in absentia.

For **metaphor in praesentia**, the two concepts (compared and comparing) are presents and despite the absence of the comparison tool, it is possible to perceive quite easily their link. That makes the comparison less allusive and relatively attenuates the expressive force of the metaphor. *Example: "The butterfly, flower without stem" (Nerval)*. The butterfly is compared to a flower to enhance its splendor. This metaphor can be expressed in description logics by:

$$\begin{aligned} Flower &\equiv Butterfly \\ Flower \sqcap Butterfly &\equiv \exists beingSplendid.\top \end{aligned}$$

The **metaphor in absentia** is characterised by the unique presence of the comparing concept and the absence of the comparative one whose existence is insinuated by the context. *Example: "My bitter mind, a worried and crazy wing flies over the sea" (Verlaine)*. The comparing "mind" is clearly expressed while the compared "bird" is guessable through the words "wing" and "fly" which are part of its lexical field. It is a metaphor that is not expressed openly, the link between the comparing and the compared is made by logical inference. This example can be expressed in description logics as shown below:

$$\begin{aligned} Bird &\subseteq \exists hasWing.\top \sqcap \exists canFly.\top \\ \exists hasWing.\top \sqcap \exists canFly.\top &\equiv Mind \sqcap Lightness. \end{aligned}$$

By transitivity, we could deduce that  $Bird \subseteq Mind \sqcap Lightness$ .

There are others types of metaphors, such as the spun metaphor, which adds new terms borrowed from the lexicon of another metaphor so that to complete the meaning of the latter and intensify its effect, or the lexicalised metaphor (or catachresis), it is a metaphor that, throughout its use, is fully integrated into everyday language (e.g *the saw's teeth; the armchair's arm; etc.*). Examples of these metaphors and their formalisation in description logics are:

<sup>16</sup>SWRL - Semantic Web Rules Language, is the language which allows to build Horn clauses (logical rules of inferences). It helps to extend the expressiveness of some OWL's (Ontology Web Language) variants by allowing them to create complex rules. OWL is another language dedicated to creating ontologies for the Web. It has many variants: OWL-DL (corresponds to SHOIN (D)), OWL-Lite (uses fewer constructors), OWL-Full (OWL complete, which is undecidable).

In **spun metaphor**, an equivalence axiom connects the comparing to the intersection of the compared with the common concept. As for the union of the new metaphorical terms added, it is subsumed by the set of things which have at least one instance of the "lexicalElementOf" property to the comparing concept. *Example: "This woman is a flower; the corolla of her face obsesses me, the petals of her cheeks intoxicate me"* can be expressed in description logic like :

$$\begin{aligned} Flower &\equiv Woman \sqcap Beauty \\ Corolla \sqcap Petals &\subseteq lexicalElementOf.Flower. \end{aligned}$$

In **lexicalized metaphor (catachresis)**, the frequent use of this metaphor eventually makes it lose its poetic power. That then leads to its total assimilation to everyday language. As a result, meronymic relation have been created between comparators and compared. For example:

$$Arm \subseteq \exists elementOf.Armchair ; Sunset \subseteq \exists phaseOf.Sun.$$

Besides the textual form, the expression of a metaphor can be visual. These metaphors are images that contain underlying metaphors, visible through shapes or symbols that embody phenomena, events, characters or others. The work we are doing allows to formalise the expression of the visual metaphor within medieval illuminations, in the OWL language, so that to express the influential relations they contain. The specification and formalisation of these influential relations will be subject of incoming work.

## V CONCLUSION AND FUTURE WORKS

This paper presents an ongoing research combining techniques from the knowledge engineering and the historical analysis of medieval documents. This work allowed us first of all to identify the process of design and distribution of illuminations as a medieval expression of a social network. This social network obeys the same motivations and codes as the current social media. Nevertheless, this system of expression of knowledge uses more complex types of relations such as metaphors. To help the illuminations interpretation's process and to develop a computerised system for understanding metaphors, we have proposed a formalisation's approach of a domain ontology in description logics. This ontology described in SHOIN(D) allows medievalists to describe the components of illuminations using a web interface and to encode the reasoning associated with metaphors in the form of logical rules. In future work, we plan to combine our ontology with systems of semantic representation of current social media. The goal is to eventually propose a functional extension of these social media in the objective to improve the calculation of the influence of these members, through a qualitative analysis.

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<b>Concept</b>	<b>Relationship</b>	<b>Individual</b>
Animal Duke	hasChild(Person, Person) hasFather(Person, Person)	Place(PALACE, ROOM) ExtraProfessionnalActivity (READING, FALCONRY, DANCE, MUSIC, BATH)
DucalCourt Knight Advisor	toReunited(Person, Duke) bePositioned(Person, Position) beKneelingInFront(illuminator, Duke)	
TheCount Writer Book Illumination	offered(Book, Duke) talk(Duke, Person) paint(Book, Writer) holdUnder(Duke, canopy)	ProfessionnelActivity (DECISION, POLI- TIQUE, JUSTICE, DIPLOMATIE, FI- NANCES, COMMAN- DEMENT MILITAIRE)
Illumination Collar GoupToisonDor Activity Greyhound Person Shoes	look(GreenKnight, Duke) beRelated(Person, Person) wear(Person, Clothes) beOut(Writer, Framework) named(Duke, Person) interested(Person, Activity) beMember(Person, GroupToison- Dor)	
ProfessionnalActivity ExtraProfessionnalActivity Positioning CommandStaff Assembly	composer(Assembly, Personne) hasOld(Person, integer) surround (Personn, Duke)	

Table 1: The ontological components contained in the illumination of the figure 1. The lists of concepts, relations and individuals in this table are not exhaustive. They only present a slice of this illumination's components. In a relation, a variable's name beginning with a capital letter means it is a concept we suppose already defined.



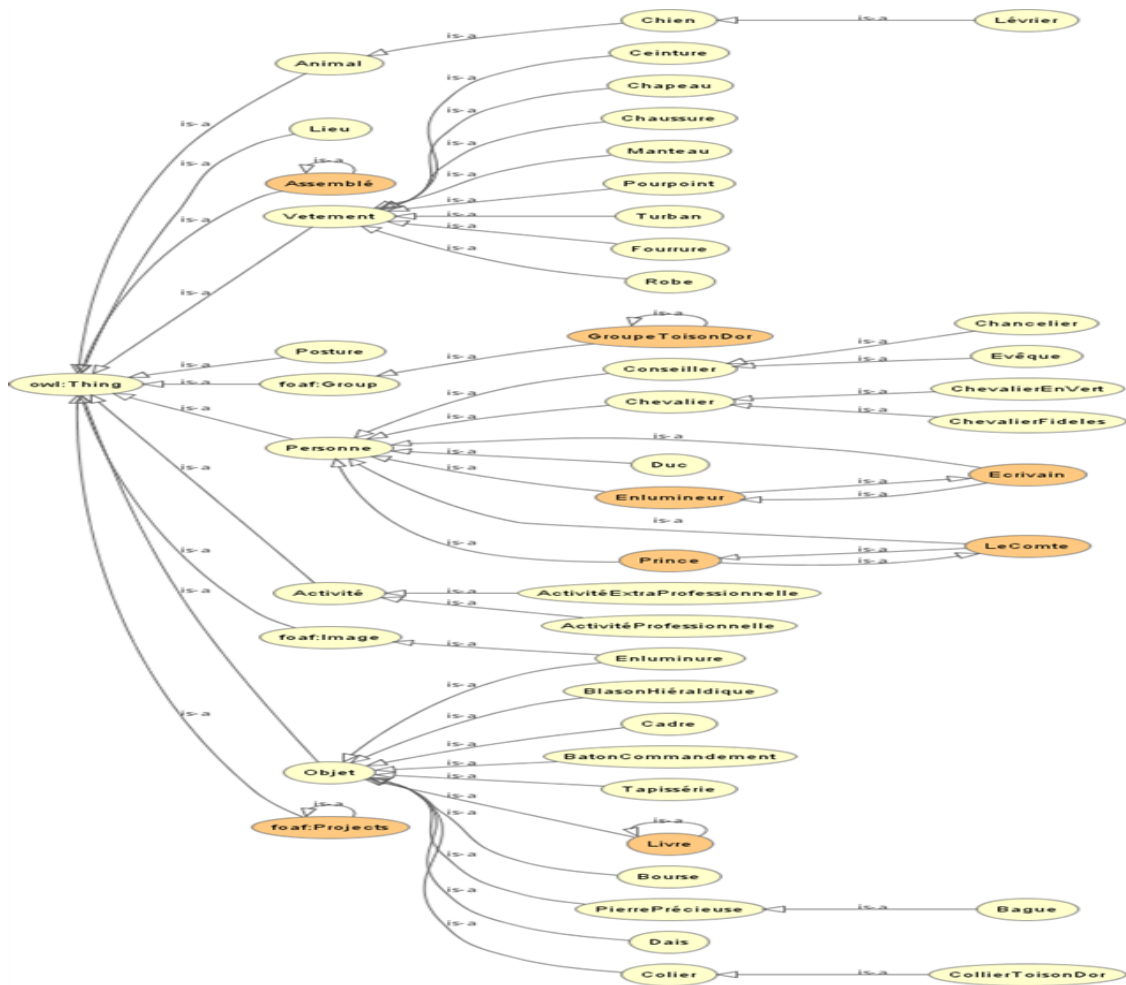


Figure 2: A view in Protege 2000 of some concepts of illumination of the figure 1. These concepts are organised through the subsumption relation (*is - a*).

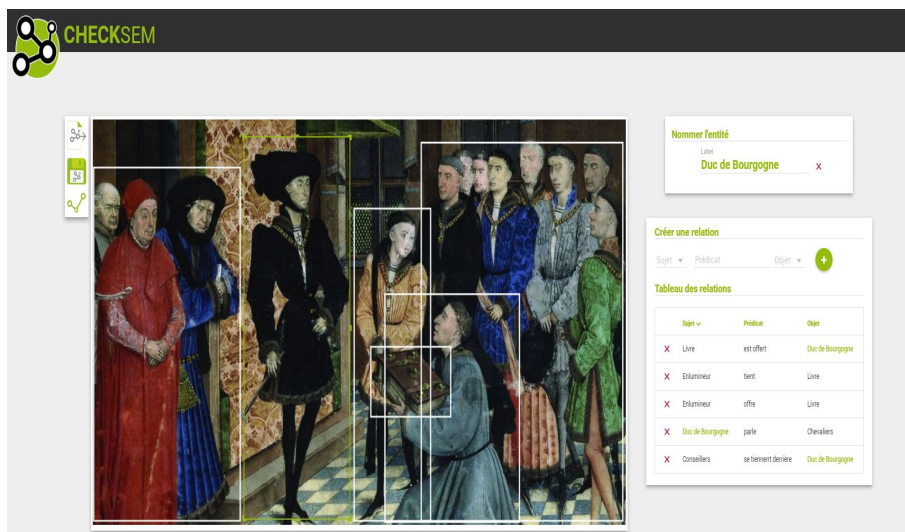


Figure 3: An interface of illumination annotation's tool we are implementing.

<p><b>- Symbolic relationships</b>  <b>Formalisation in Horn Clauses</b></p>
<p>- a knight has the right to kill  <math>hasRightToKill(X) : \neg Knight(X)</math></p>
<p>- a knight is a monk wearing the necklace of the Golden Fleece  <math>Knight(X) : \neg Monk(X), GoldenFleeceNecklace(Y), wear(X, Y)</math></p>
<p>- a person carrying a weapon has the right to kill  <math>hasRightToKill(X) : \neg Person(X), Weapon(Y), carry(X, Y)</math></p>
<p>- we are submitted to a person in front of whom we stand in a submission position  <math>beingSubmitted(X, Y) : \neg Being(X), Person(Y), SubmittedPosition(Z), beIn(X, Z)</math></p>
<p>- being submitted to someone is to be faithful to him  <math>faithful(X, Y) : \neg beingSubmitted(X, Y)</math></p>
<p>- being a felon to the Duke is to be unfaithful to him  <math>beingFelon(X) : \neg \neg faithful(X, Y), Duc(Y)</math></p>
<p>- a felon wears green clothes  <math>beingFelon(X) : \neg Person(X), Clothes(Y), GreenColor(Z), hasColor(Y, Z), wear(X, Y)</math></p>
<p>- a person in mourning dresses all in black  <math>beingInMourning(X) : \neg person(X), Clothes(Y), BlackColor(Z), hasColor(Y, Z), wear(X, Y)</math></p>

Table 2: Some examples of symbolic or implicit relations in the illumination depicted in the figure 1 and their formalisation with Horn Clauses. We suppose that all the explicit concepts and relations in the right side of a clause are well defined. Example:  $GreenColor(X)$  defines the green color,  $hasColor(X, Y)$  means a thing X has the color Y,  $Monk(X)$  is the concept which designates a monk, etc.