



**HAL**  
open science

# Causal reasoning and symbolic relationships in Medieval Illuminations

Djibril Diarra, Martine Clouzot, Christophe Nicolle

► **To cite this version:**

Djibril Diarra, Martine Clouzot, Christophe Nicolle. Causal reasoning and symbolic relationships in Medieval Illuminations. 2018. hal-01762730v1

**HAL Id: hal-01762730**

**<https://hal.science/hal-01762730v1>**

Preprint submitted on 10 Apr 2018 (v1), last revised 3 Jun 2019 (v5)

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Causal reasoning and symbolic relationships in Medieval Illuminations

Djibril Diarra<sup>1</sup>, Martine Clouzot<sup>2</sup>, Christophe Nicolle<sup>1</sup>

<sup>1</sup>Laboratoire Electronique Informatique et Image (LE2I), Burgundy University, France

<sup>2</sup>Laboratoire Archeologie Terre et Histoire (ArTeHis), Burgundy University, France

Corresponding author: Djibril Diarra, dl4djibril@gmail.com

## Abstract

This work applies some knowledge engineering techniques to medieval illuminations. In this article we consider an illumination as a graph of knowledge. This graph was used by elites in the Middle Ages to represent themselves as a social group and to represent their lives events. To do this, combinations of symbolic elements are used to encode influence messages more or less implicit. Our work is to identify the meaning of these elements through a logical modeling approach using ontologies. The ultimate idea is to identify logical reasoning rules and to simulate them using artificial intelligence mechanisms, on one hand to facilitate the interpretation of illuminations regard to the context and on the other hand to provide a logical formalization of new encoding and information transmission services in the future evolutions of current social networks.

## Keywords

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

## I INTRODUCTION

Knowledge engineering aims to logically formalise human knowledge so that it can be manipulated by computerised systems. In this paper, this science is used to characterise and formalise symbolic relationships between concepts. Medieval illuminations are images which were in the Middle Ages designed and used by elites to represent their lives events but also to represent themselves as a social group. They constitute an information system based on symbolic relations whose meanings and messages are determined in a particular and evolving context. They can be represented by knowledge graphs. The strong correlations of structures between the medieval illuminations and the social networks requires first to explain by which processes the illuminations served as a visual support for the social communication of the time. Even if the power of images is explicitly to represent scenes, implicitly they above all aim to act on the cognitive perceptions of users and therefore on their behavior. The medieval illuminations treated in our works only designate those relating to the court of Burgundy Duke (cf 3.1), Philippe The Good<sup>1</sup>. They were realised, for the Duke, with the implicit goal of exercising influence on his various social networks : families, knights, allies, enemies, other European princes, competitors, etc. This influence can be seen in the circulation, the imitation or the diversion of the illuminations : implicit messages circulate in the networks, which reuse them and produce new ones. These medieval illuminations can be considered as the first social networks and help to enrich the structures of current and future social networks.

---

<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 time (1337-1453).

The main issues that face us are in one hand the abundance of symbolic relations medieval illuminations contain. To highlight their meaning in an illumination, its components must be specified and formalised properly. On the other hand the strong correlation of these components gives rise to new knowledge which can be inferred from the made explicit ones.

### 1.1 Research objectives

We aim to identify the meaning of symbolic elements and semantic relations in medieval illuminations through a logical modeling approach using ontologies. Combinations of symbolic elements are used to encode influence messages more or less implicit. These combinations allow to describe and analyse symbolic elements figured in the images. To do this, we develop computerised tools and ontologies to capture and model the meaning of symbolic elements and their relationships. Beyond a simple taxonomic modeling, we can constrain the built the illuminations 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 allows us to build reasoning rules and use a triplestore<sup>2</sup> inference engine. So that our computerised system could be able to reason on graph elements representing the illuminations to discover new implicit knowledge.

### 1.2 Document's Organisation

In this document remaind, first we will present some works related to ours, our vision on social networks and show the correlations between illuminations and these networks. Then we will present an illumination and detail the associated historical context. After that we will propose an ontology of these illuminations with some examples of formalised symbolic relationships. And we will present an interface of our tool in implementation for the illuminations annotation. Finally we will conclude and give some future work perspectives.

## II RELATED WORKS

In general, the ontologies use for knowledge graphs representation is not new and numerous works treat it. More specifically for social networks which are knowledge graphs composed of entities linked by social ties, a famous ontology has been modeled: the FOAF<sup>3</sup> ontology. His specification is detailed in the [Brickley and Miller, 2007] works. It serves as a basis for showing the similarity between illuminations and a social network. In addition, our illuminations ontology uses it, extends it to be more precise in our description. Regarding the medieval images description, cultural heritage in general, the [Dörr, 2002] author proposes an ontology (CIDOC object-oriented Conceptual Reference Model, CRM) that models information on cultural heritage. It formally describes the concepts and relationships underlie the document structures used in this area. This ontology is very general because it tries to cover any type of document used in the cultural heritage field. The one we propose also contributes to the digitisation of the cultural heritage but it is specific to the Burgundy Duke illuminations. The [Doerr et al., 2006] authors extend the CRM by combining it with another that describes the digital library field. This promotes knowledge integration. Our ontology similarly can be extended to other models (FOAF, for example). 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.).

---

<sup>2</sup>A triplestore is a database specially 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, a triplestore stores data and retrieves it via a query language

<sup>3</sup>FOAF, Friend of A Friend is a popular ontology that describes the social relations between entities and their interests in a social network

Thus the [Hyvönen, 2012] author gives an insight about when, why and how to use Semantic Web technologies in practice to publish cultural heritage knowledge on the Web. He evokes most of the formalisms we use in our work. The main reasons which motivate us are: the explicit or implicit knowledge extracted from illuminations sharing, their interoperability and integration with other similar knowledge and the provision of a valid model which helps the development of computerised systems used in cultural heritage knowledge management.

### III SOCIAL NETWORK AND MEDIEVAL ILLUMINATIONS

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

All of these works require a large and variable set of information in different contexts where the notion of social network refers to any relationship involving regular social interactions between individuals, organizations, companies, regions, countries, etc. These relationships are based on acquaintances, collaboration, collegiality, friendship and so on. They can be direct (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 ( $A \rightarrow B$  implies  $B \rightarrow A$ ) or asymmetric ( $A \rightarrow B$  does not involve  $B \rightarrow A$ ).

Any social network is maintained by resource sharing operations which can be material (money, livestock, food, equipments, weapons) or not (informations, strategies, decisions, mood, activities). More the members reactions on these resources and their multi-stakeholder sharing in the network are high, the more dense and important it becomes. These operations are one of the fundamental characteristics of a social network, represented by a virtual community: website on the internet (Facebook<sup>4</sup>, LinkedIn<sup>5</sup>, Viadeo<sup>6</sup>, Twitter<sup>7</sup>, etc.) or real community of the life.

To sum up, a social network is a set of representations (avatars) of real or moral persons; contributors in a computerised platform or not, by messages or documents; and who are encouraged to interact explicitly or implicitly with this disseminated information. The majority of the current social networks is structured around the valuation of the "me" of the real users through their avatar.

#### 3.1 Illumination : definition and design principles

This representation of the "me" and "my" environment is a constant in the humanity history. Rock paintings illustrated a vision of an activity which was transmitted on a horizontal support, writing and drawing (as opposed to oral transmission, called vertical). In the Middle Ages, to address to the educated social categories, the illuminations were developed in books. An illumination is a fixed painting, made on a manuscript parchment 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 describing semantic and symbolic relationships between objects, ideals, characters expressing concepts and conveying explicit and implicit messages. It

---

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

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

<sup>6</sup>[www.viadeo.com](http://www.viadeo.com)

<sup>7</sup><https://twitter.com>

is structured according to positioning relationships (topology), hierarchy, semantic relationships (for example meronymy) and metaphorical relationships (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*, literally meaning the replacement of the proper term by an imaged term, responding to an implicit comparison [Pernot, 1993]. It is done according to four modes: 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 relationships are very abundant in the illuminations we treat : the illuminations of the ducal court.

The ducal court is 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 is a vast principality from the south of actual Burgundy to Amsterdam. Its territorial possessions are partly rural, but also very urbanized (Brussels, Bruges, Ghent, Dijon, Lille, etc.). Different social groups in its network (bankers, shopkeepers, academics, townspeople, etc.) also operate in more or less wide networks. The illumination of the figure 1 illustrates a network composed of the Duke, his son the Count, the Advisors, the Knights. Together they constitute the closed social network symbolised by the Golden Fleece collar.

In illuminations, certain objects, characters or the image as a whole are also considered as a sign (sometimes stronger than metaphor or working by means of metaphor). An illumination is always performed in a scholar, religious or profane context. It is part of a communication chain from the sponsor (here, the Duke of Burgundy), the author (illuminator) or the copyist of the book to the addressee (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 level and it aims to represent an ideal image of himself, his family, his society in the past , the present, the future (after death). Implicitly it serves to convey ideas, idealised relationships, chivalrous and religious values. Explicitly it represents scenes of court life such as banquets, weddings, balls, tournaments, etc. The scenes it describes and their meanings are not fixed, they vary according to the contexts. These event scenes are selected by a writer (the illuminator, the person who paints the images) and drawn as an image. These images serve as information vehicles about the Duke and the ducal court activities and are presented to the public during future political events such as the luxurious manuscript donation to the Duke (scene described in the Duke illumination depicted by the figure 1), a banquet or a large knights assembly.

### **3.2 Correspondence between illuminations and social networks**

From these virtues and uses, an illuminated book is a social network like Twitter or LinkedIn, in terms of communication tool and resource sharing. However an illumination in itself can be assimilated to an animation or upkeep resource of a social network (the Duke social network) insofar as it tells and shares with the network members a history. Its aim is thus to show the Duke influence, to exercise it and to convey it. These influences are deduced through certain relationships in the illumination such as :

- the submission 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;



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*

- the command of the Duke; he holds a command stick.

#### IV SEMANTIC FORMALISATION OF ILLUMINATIONS

This part is dedicated to our semantic formalisation of illuminations. A brief description of the concepts and terms used is made as and when the different results are presented.

##### 4.1 Ontological Modeling of an Illumination and Fundamentals on the Terms and Formalisms Used

Etymologically linked to the theory of the existing, the term "ontology" admits many definitions in the literature, because it is applicable to many fields (philosophy, information sciences, linguistics, knowledge engineering, artificial intelligence, etc.). In our project, we will retain the [Studer et al., 1998] definition: "*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 domain relevant concepts, the relationships that exist between these concepts as well as rules and axioms that constrain them in their operations. The knowledge of a domain is formalised, in an ontology, using mainly five types of components which are :

- the concepts, also called classes, correspond to the relevant abstractions of the domain, retained according to the objectives and the application envisaged for the ontology;
- relationships reflect relevant associations between concepts. These relationships are hierarchical (generalisation/specialisation, aggregation/composition, instance of), associative, equivalent (synonymy, homonymy, antonymy, etc.)
- axioms are assertions accepted as true about the domain abstractions. They constrain the concepts operations and allow to infer new knowledge in the domain;
- the instances constitute the ontology extensional 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 relationships (*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 bannish any significant ambiguity. This provides a uniform knowledge base for the user 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 representations because of its expressiveness, decidability and mastered complexity. Its constructors (the set of lexical symbols and operators used in the 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 subvariant composed of operations - the global concept definition (Top, represented by  $\top$ ), the concept of nothing (bottom,  $\perp$ ), any concept (*Duc* for example), concepts conjunction (*Duc AND Knight*,  $Duc \sqcap Knight$ ), universal quantification (All the Duke's children,  $\forall child.Duc$ ) and existential (the Count's father,  $\exists father.TheCount$ ), and negation of a concept (not Animal,  $\neg Animal$ ) and constructor R+ (which allows the roles or relations composition. *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 for instances. *Example: games, banquet are activity instances,  $Activite\{games, banquet\}$* ;
- **I**: to design the inverse of a role (a relation). *Example: the child relationship is the inverse of father,  $child.\top \equiv \exists father^{-1}.\top$* ;
- **N**: 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 define other concepts or to organise them through rules (or axioms).

The table 1 presents some concepts, relations and individuals of the illumination depicted in the figure 1. Figure 2 describes a view of the concepts of illumination, modeled in Protege<sup>8</sup>.

This modeling, once finished can be retrieved in a formal syntax form in a language<sup>9</sup>, such as RDF/XML, Turtle or OWL, generated by the tool. It is extensible and can be combined with other 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 that allows to select an illumination and semantically index its components. On this platform accessible via a web browser, it is possible to download a digital version of an illuminated image (in jpeg or png format). Then graphic selection tools are used to frame important elements in the image as concepts. Once these concepts are indexed, it is possible to build semantic relationships between them. This allows to extend the ontology. The verification of the added relationships and the definition of inferences is not yet treated and will be the subject of future works.

Nevertheless the annotation of the concepts and their relationships are made manually according to a list of these concepts and relations provided by the experts. This guarantees a certain

<sup>8</sup>Protege is a software tool dedicated to ontology modeling. <http://protege.stanford.edu/>

<sup>9</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

coherence in the concepts and relations indexed. The figure 3 illustrates an interface of this platform. It shows us some annotations made and related in the illumination of the figure 1. Annotations and relationships created can be retrieved and saved in JSON format<sup>10</sup>. This file is built to be able to extend the ontology on both its Tbox (the set of concepts of an ontology and their relationships) and on its Abox (the set of instances, facts or individuals in the model).

The construction of this ontology is realised from the medievalists expertise. The built one can be queried by SPARQL<sup>11</sup> queries. The interest of ontology is its ability to discover new knowledge from initial ones. This discovery is achieved by the construction of logical rules and their application within an inference engine. Beyond our terminological description of illuminations, certain elements of symbolic interpretations remain to be defined through the formulated logical rules. We are currently working on the construction of these rules in SWRL language<sup>12</sup> (Semantic Web Rules Language) so that to reason about symbolic relationships within an illumination. In the one depicted in the figure 1 some examples of symbolic relationships and their formalisation with Horn clauses are in the table 2.

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

The logical rules construction in the Horn clauses form will enable us to interpret metaphors, numerous 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 establish 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 has been no mutual 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 present and despite the absence of the comparison tool, it is possible to perceive quite easily the link that unites them. 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 thanks to the words wing and fly which are part of its lexical field. It is a metaphor that is not expressed openly, the link between

<sup>10</sup>JSON (JavaScript Object Notation) is a lightweight data exchange format. It is easy to read, write and analyse

<sup>11</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

<sup>12</sup>SWRL - Semantic Web Rules Language, is the language which allows to build Horn clauses (logical rules of inferences). It helps extend the expressiveness of certain OWL (Ontology Web Language) variants by allowing them to create complex rules. OWL is another language dedicated to creating ontologies for the Web. It admits many variants: OWL-DL (corresponds to SHOIN (D)), OWL-Lite (uses fewer constructors), OWL-Full (OWL complete, which is undecidable).



the comparing and the compared is established 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 can deduce that  $Bird \subseteq Mind \sqcap Lightness$ .

There are other types of metaphors, such as the spun metaphor, which adds new terms borrowed from the lexicon of another metaphor in order 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 teeth of a saw*, *the arm of an armchair* ...). Examples of these metaphors and their formalisation in description logics are :

**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 that 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 :

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

**lexicalized metaphor (catachresis)**, the frequent use of this metaphor eventually makes it lose its poetic power, leading then to his total assimilation to everyday language. As a result, meronymic relationships 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 relationships they contain. The specification and formalisation of these influential relationships will be subject of incoming work.

## V CONCLUSION ET FUTURE WORKS

This paper presents an ongoing research combining techniques from the field of knowledge engineering and the field of historical analysis of medieval documents. This work allowed us first of all to identify the designing and distributing process of illuminations as a medieval expression of a social network. This social network obeys the same motivations and codes as the current digital social networks. Nevertheless, this system of expression of knowledge uses more complex types of relationships such as metaphors. To help the illuminations interpretation process and to develop an automatic system for understanding metaphors, we have proposed a formalisation approach in description logics of a domain ontology. 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 networks. The aim is to eventually propose a functional extension of social networks in the objective to improve by a qualitative analysis the calculation of the influence of these members.

## VI ACKNOWLEDGMENTS

This work is funded by the CNRS as part of a PEPS project, the French Embassy in Bamako and the Malian government for the cofunding of a thesis, the Burgundy Region Franche-Comté and the University of Burgundy. We would like to thank all these institutions as well as Mr. Rafik Zebidi and Mr. Florian Lacroix for their help on the metaphors formalisation and implementation parts.

## References

- Franz Baader. What's new in description logics. *Informatik-Spektrum*, 34(5):434–442, 2011.
- Franz Baader, Ian Horrocks, and Ulrike Sattler. Description logics as ontology languages for the semantic web. In *Mechanizing Mathematical Reasoning*, pages 228–248. Springer, 2005.
- Eytan Bakshy, Itamar Rosenn, Cameron Marlow, and Lada Adamic. The role of social networks in information diffusion. In *Proceedings of the 21st international conference on World Wide Web*, pages 519–528. ACM, 2012.
- Dan Brickley and Libby Miller. Foaf vocabulary specification 0.91, 2007.
- Martin Doerr, Jane Hunter, and Carl Lagoze. Towards a core ontology for information integration. *Journal of Digital information*, 4(1), 2006.
- Martin Dörr. The cidoc crm-an ontological approach to semantic interoperability of metadata, 2001. *AI Magazine, Special Issue on Ontologies*, Nov, 2002.
- Tom Gruber. What is an ontology. WWW Site <http://www-ksl.stanford.edu/kst/whatis-an-ontology.html> (accessed on 07-09-2004), 1993.
- Eero Hyvönen. Publishing and using cultural heritage linked data on the semantic web. *Synthesis Lectures on the Semantic Web: Theory and Technology*, 2(1):1–159, 2012.
- Damien Leprovost, Lylia Abrouk, and David Gross-Amblard. Discovering implicit communities in web forums through ontologies. *Web Intelligence and Agent Systems: An International Journal*, 10(1):93–103, 2012.
- Eugenio Martínez-Cámara, M Teresa Martín-Valdivia, L Alfonso Urena-López, and A Rturo Montejo-Ráez. Sentiment analysis in twitter. *Natural Language Engineering*, 20(1):1–28, 2014.
- Laurent Pernot. *La rhétorique de l'éloge dans le monde gréco-romain: Histoire et technique*, volume 137. Institut d'études augustiniennes, 1993.
- Philippe Perrenoud. D'une métaphore à l'autre: transférer ou mobiliser ses connaissances? In *L'énigme de la compétence en éducation*, pages 45–60. De Boeck Supérieur, 2002.
- Elie Raad. *Découverte des relations dans les réseaux sociaux*. PhD thesis, Dijon, 2011.
- Faneva Ramiandrisoa and Josiane Mothe. Profil utilisateur dans les réseaux sociaux: Etat de l'art. In *CORIA*, pages 395–404, 2017.
- Rudi Studer, V Richard Benjamins, and Dieter Fensel. Knowledge engineering: principles and methods. *Data & knowledge engineering*, 25(1-2):161–197, 1998.

<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 illuminated figure 1. The lists of concepts, relationships and individuals in this table are not exhaustive. They only present a portion of this illumination components. In a relationships, a variable name beginning with a capital letter means it is a concept we suppose already defined.

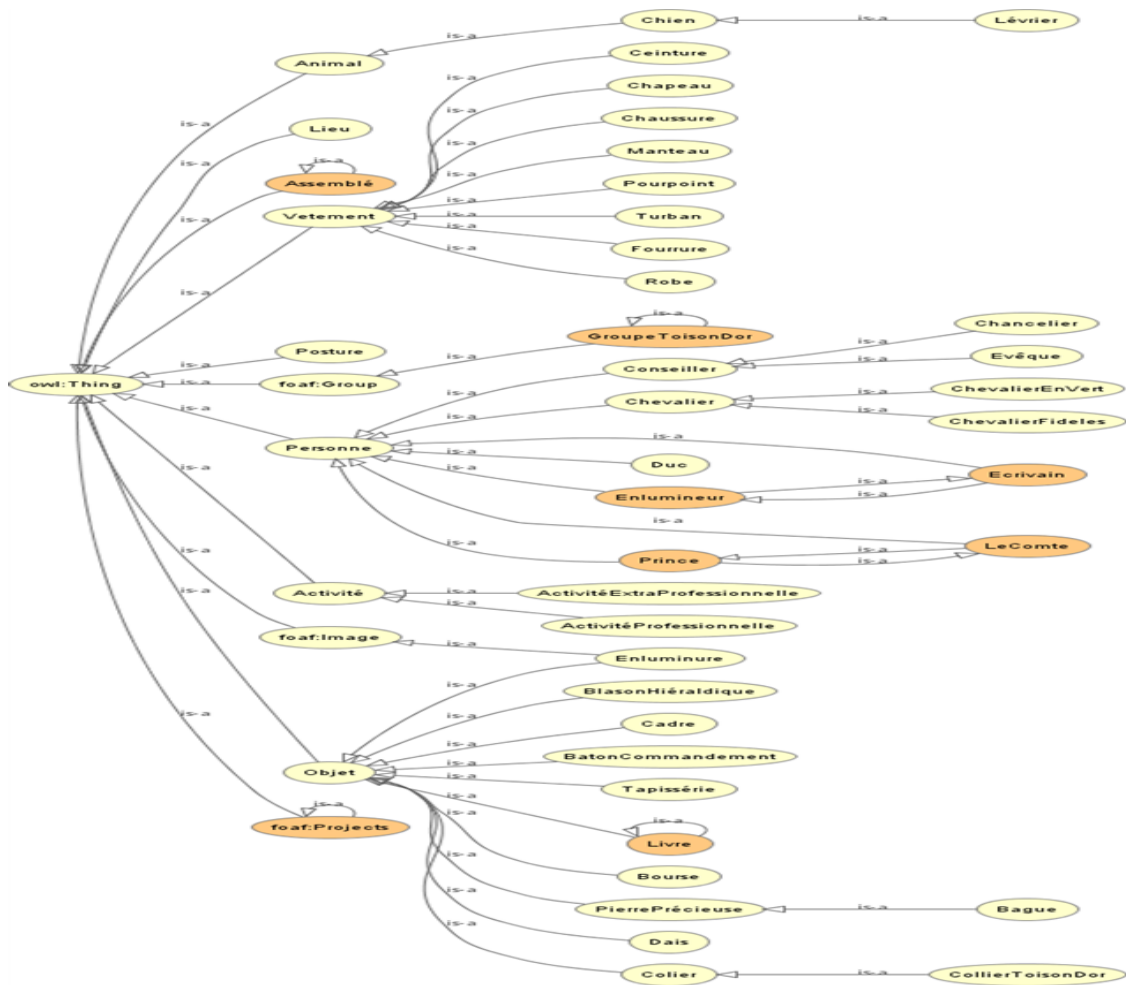


Figure 2: A view in Protege 2000 of some concepts of illumination of the figure 1. These concepts are organised through the subsumption relation (*is - a*).

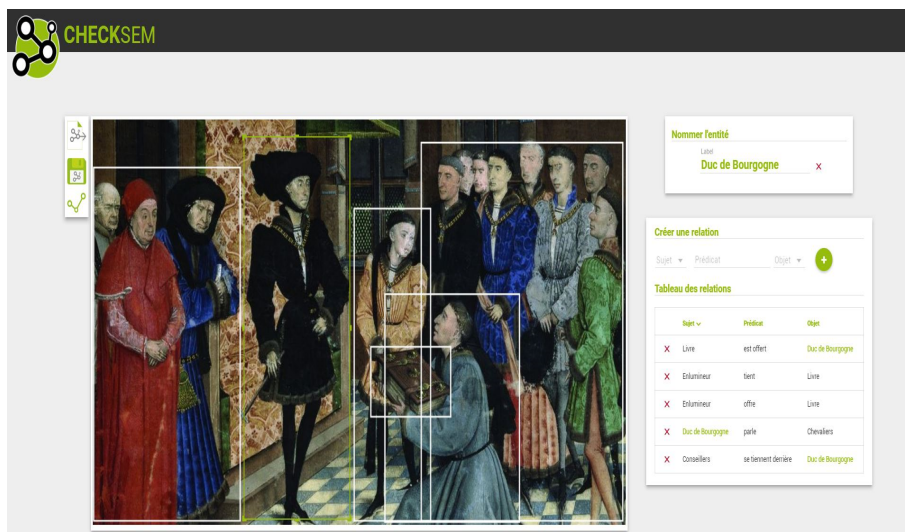


Figure 3: An interface of illumination annotation tool we are developing.

<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 symbolics or implicits relationships in the illumination depicted in the figure 1 and their formalisation with Horn Clauses. We suppose that all the explicit concepts and relationships 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 designs a person in monk, etc.