

# An Ontology for Property Crime based on Events from UFO-B Foundational Ontology

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**Abstract**—Property Crime has been highlighted as one of the major criminal offenses within the Brazilian Legal System. Moreover, it is common that there is some misunderstanding amongst the subtypes of this crime, such as Theft, Robbery, Misappropriation, and Extortion. We still emphasize the very nuance of legal literature that makes this domain as hostile as challenging: a weakly formalized knowledge, the presence of conflicts and ambiguities between norms, the heterogeneity of legal literature, as well as the diversity in reasoning models. Therefore, this article presents, inspired by UFO-B foundational ontology, a conceptual model for the representation of crimes against property in the Brazilian Criminal Code, in order to support some decision-making process, as the agents behavior classification and the inference of punishments. Thus, we present throughout this article, an ontological formalization for the Theory of Crime from Brazilian Penal Code, as well as for Property Crimes applications.

**Index Terms**—Legal Knowledge Representation and Reasoning, Ontology, Property Crime.

## I. INTRODUCTION

The Legal Literature representation and the inference of new knowledge from a tangled basis of norms, legal documents, case law, as well as the retrieval of relevant information are tasks commonly adopted by the interdisciplinary field of research known as Computational Law [1]. Some special features make the legal domain very challenging, as poorly formalized knowledge, the presence of conflicts and ambiguities between norms, the heterogeneity of legal literature, and also the diversity in reasoning models.

Very different from countries whose legal system is built upon similar cases, the Brazilian Legal System adopts the civil law. Briefly, each law is composed by two well-defined parts: the conduct (the primary precept) and the punishment (the secondary precept). The heart of the Brazilian Legal System is the National Federal Constitution (1988), providing the legal instruments of the entire Brazilian legal system. The Criminal Law, in particular, is referred to as the set of legal rules that define criminal offenses, establishing punishment and security measures. In short, the criminal law establishes definitions about the crimes, their types, and criminal penalties. Unfortunately, the rhetoric and flowery language commonly adopted brings interpretative problems in the writing of Brazilian law. Besides the possibility of dubious interpretation, the

heterogeneous source of official documents (Complementary laws, Regulations, Decrees and Interim Measures) needs to be evaluated together to resolve non-trivial conflicts.

Given the wide variety of crimes, the formalization of the Criminal Law through a shared conceptualization-taxonomy opens a range of possibilities: on the one hand, it avoids the problems arising from the flowery language used in laws, on the other, makes possible the development of intelligent systems capable of classifying human behaviors and typical penalties for the norms violation. From this perspective, the article presents an ontological formalization for the Theory of Crime of Brazilian Law System, as well as an application Ontology covering offenses within Property Crime domain, such as: Theft, Robbery, Robbery with death, Damage, Extortion and Misappropriation. The choice for this particular application, was guided by two criteria: currently, it represents a major recurring criminal type in everyday life in Brazil; further, eventually, some confusion arises among its subtypes, given the similarity in the writing of the law.

Regarding the recent development of the Semantic Web open standards, we had used as a paradigm for the representation of knowledge, the Description Logic [2]. In addition, through the foundational ontology UFO-B [3], the agents' behavior was conceived in terms of events and states. Throughout this paper, we present the formalization of these crimes, followed by a case study and some remarks.

## II. LEGAL COMPUTING

Legal Computing [1] (or Computational Law) is an interdisciplinary research field which addresses both the use of strategies for the representation of legal knowledge, as the possibilities for creating automated reasoning systems (for Argumentation, Legal Action simulation, Criminal Classification, among other tasks). While to acquire, manipulate and manage legal knowledge are highly expensive tasks given the enormous quantity and variety of these normative documents, the advent of Computational Law is justified both by the need for systems that assist lawyers and judges in decision-making [4] as the very need to automate the indexing and organization of legal cases in every legal field [5]. Furthermore, it is worth noting the need to democratize access to legal documents, the

ability to compare different legal systems, even from different countries, as well as the very natural evolution of the laws.

The integration between Artificial Intelligence (A.I.) and Law did not happen by chance. There is a set of characteristics inherent in the Legal System, that promotes cohesion between these areas. It stands out the heterogeneity of legal documents as well as the different types of knowledge that the Legal Science addresses. In particular, the framework developed by [6], for example, describes these types of knowledge, their relationships, and functions: Normative, Meta-knowledge, Responsibility, Reactive, World Knowledge and Creative Knowledge. In addition, Principles, Case Law, Doctrine, and other artifacts have created a tangle environment, but at the same time, suitable for knowledge representation and reasoning.

### III. BRAZILIAN CRIMINAL LAW AND THE PROPERTY CRIME

In Brazil, the Criminal Law is referred to as the set of legal rules that define criminal offenses, establishing punishment and security measures. In short, the criminal law establishes definitions about the crimes, their types, and criminal penalties. Legally, the criminal law is formed by the Brazilian Penal Code<sup>1</sup> (Decree Law 2.848 dated 1940), having been extensively renovated by Law 7209/1984. Currently, the design of a new penal code (Senate Bill, PLS 236/2012) is in progress. The Legal System is governed by norms, which specializes in rules (the law, itself) and principles. The former, with more specific nature, dictates about situations or behaviors that are prohibited or permitted, and additional conditions for classifying the behavior as being at low (preferred) or high risk (qualified) to the social good. Associated with criminal behavior, emerges the norms typicality, which is a legal causation designating penalties arising from the action (or omission) of an agent. Unlike, the principles configure general guidelines to support the laws or to close any gap left by them. In this paper, we focus only on the Laws.

Crimes against Property correspond to the protected legal interest in the crimes set out in Articles 155-180 of the Brazilian Penal Code. Beyond the economic value, for criminal purposes, the value of assets covers also the moral value of goods, as a letter, a stone, or any material object that has affection value to the owner, although it does not have exchange value. Crimes against property include:

- **Theft:** *To take a chattel<sup>2</sup>, for himself or others, without the owners consent.* (Art. 155)
- **Robbery:** *To take a chattel, for himself or others, by serious threat or violence to a person [...].*(Art. 157)
- **Extortion:** *To embarrass someone by violence or serious threat, in order to obtain for himself or others, undue economic advantage [...].* (Art. 158)
- **Robbery with death<sup>3</sup>:** *If the violence results in serious bodily injury, the punishment is imprisonment from seven*

*to fifteen years plus fine; if it is death, the jail time is twenty to thirty years.* (Art. 157, § 3º)

- **Damage:** *To destroy, render useless or deteriorate something from other.* (Art. 163)
- **Misappropriation:** *To take ownership of a chattel for himself, from someone who has possession.* (Art. 168)

It is important to note that some concepts were slightly modified with respect to the English language to suit the specific characteristics and types defined in the Brazilian penal code. In addition, these articles include other cases that are derived from these, but in circumstances that worsen or alleviate the basic crime, such as: stealing a sleeping person, or a theft carried out by the first-time offender.

### IV. FOUNDATIONAL ONTOLOGY: UFO-B

Foundational (or upper-level) Ontologies represent an overview of top-level, domain independent categories, from which one can build tailored conceptual models. From this perspective, these foundational ontologies allow a common and shared vocabulary for these application models, permeating the interoperability between them. In particular, UFO (Unified Foundational Ontology) [3] emerged as a proposal for unification between GFO/GOL [7] and OntoClean/DOLCE [8], in order to solve their limitations, and inherit its main features. Moreover, in order to ensure sound formalization, this top ontology is based on a number of theories from Formal Ontology, Philosophical Logic, Philosophy of Language, Linguistics and Cognitive Psychology [3].

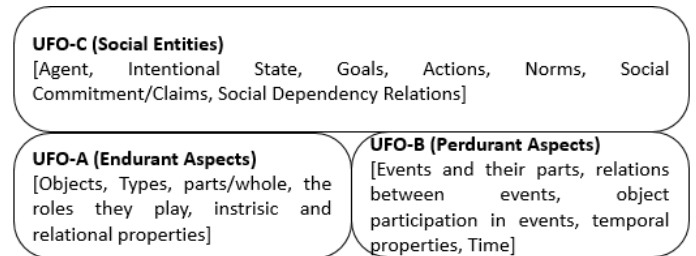


Fig. 1. Fragments of UFO

According to the figure 1, UFO is fragmented into three parts: UFO-A, UFO-B and UFO-C. UFO-A matches the objects that “are on time”, that is, those which persist in time throughout their life keeping their identity, as a person for example. They are *Endurants*. UFO-B handles Events or *Perdurants*, i.e., individuals formed by temporal parts. In other words, they “happen in time”. A musical concert, a business process, a game of chess, a Crime, and a Judicial action are categories of this type. Lastly, UFO-C is the fragment built on top of other two: it defines social entities, such as Agents, Goals and Actions.

Distinct viewpoints describe the ontology of events, as highlighted in [9]: the mereological structure of events, events as mappings from state to state, the participation of objects in events, temporal ordering of events, and events as manifestations of objects dispositions. In this work, we focus on

<sup>1</sup>[http://www.planalto.gov.br/ccivil\\_03/decreto-lei/del2848.htm](http://www.planalto.gov.br/ccivil_03/decreto-lei/del2848.htm)

<sup>2</sup>An item of personal property that is movable.

<sup>3</sup>In Brazil, it is known as “Latrocínio”.

the first two visions, as illustrated in figure 2. Regarding the mereological structure, Events, therefore, are classified in atomic or complex. In the latter case, an event is an aggregation of two or more events, which can be atomic or complex, in turn. Furthermore, Events are changes starting from an original state to a posterior state.

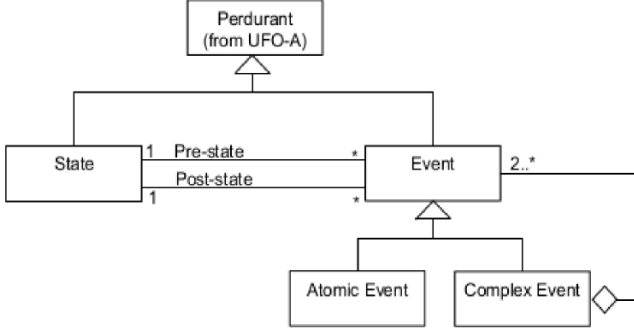


Fig. 2. An Overview of UFO-B

We chose to use the UFO-B to be able to model the different violations of individual property, in terms of events and participating states. A theft, for example, has an event “Subtraction”, which changes the world: in an initial state, one person has its wallet, and in a later stage, this agent had his wallet stolen by another agent. Aligning with the Criminal Domain, Events, therefore, are actions or omissions without which the results would not have occurred.

## V. RELATED WORK

Regarding the formalization of the theory of Crime, some related works are properly cited because of its importance and inspiration for this. The Italian Crime Ontology [10] presents a conceptual formalization to crime definition, featuring criminal conduct, additional circumstances to check worsening in punishment, sanctions and security measures, beyond the identification of those responsible for violating the laws. This work has inspired the creation of the conceptual model for the Theory of Crime.

Owl Judge [11] is a legal system that uses standard OWL 2 Description Logic reasoning for legal assessment. Owl Judge enables the construction of a generic ontology to define the concepts of norms and qualifications, where a situation or action is characterized as permitted, prohibited, or obliged. A norm is a collection of conditions, so defining a specific situation; the law thus defines deontic qualifications on the situation. Given the description of a case to be evaluated, it is matched w.r.t. the norms modeled. With the possibility of a single case match more than one norm, the system uses (only) the legal principles of *lex specialis*<sup>4</sup> to resolve the conflict and give the final verdict.

LKIF, Legal Knowledge Interchange Framework [12], is a generic architecture for the automation of legal knowledge systems, developed using Semantic Web standards such as

RDF (Resource Description Framework) and OWL (Ontology Web Language). LKIF is a library of ontologies (in total there are 15 modules) modeling the main concepts and terms of the legal and common sense domains. In addition to UFO-B, it should be noted that the LKIF was also used as Top Ontology, from which concepts such as Agents, Norms, Space/Time Occurrence and Intention, were imported.

Nevertheless, as far as we know, the literature is quite scarce regarding the formalization of Crimes against Property. In [13], we find a few references, only used as examples to explain the inferencing rules and operations concerning an ontology formalism under the Conceptual Structure Theory.

## VI. AN ONTOLOGY FOR THE THEORY OF CRIME FROM BRAZILIAN LEGAL SYSTEM

The Description Logics (DLs) [2] are a family of formalisms to knowledge representation, with support yet for reasoning tasks. DLs are generally more expressive than the predicate logic, and less expressive than first-order logic, but decidable, and applicable to many areas. For reasons of space, we will not address the syntax and semantics of the language.

The ontologies development were guided through the process known as “Methontology” [14] due its maturity, designed as a life cycle process. In order to compose these ontologies, all relevant information was extracted exclusively from official texts in a middle-out strategy: from a list of relevant terms, we proceeded with the specialization and/or generalization of concepts whenever necessary. Although the huge amount of information required, complex concepts are created when needed.

OntoCrimeAlpha is the formal definition for the Theory of Crime in the Criminal Law. From an analytical point of view, Crime is a typical, illicit and culpable behavior. In other words, a Crime is realized with the presence of these situations: the conduct is typified in some law, there is no extra circumstance that excludes unlawfulness (such as self-defense), and the agent responsible for the act is attributable, respectively. Therefore, in order to model the concepts of this domain, from a generic term, the most important and necessary concepts were created. OntoCrimeAlpha is an evolution of [15]. A brief research in the Theory of Crime reveals some macro concepts such as Agent, Behavior, Legal Document, Intent, Object, Space/Time Occurrence, Punishment and Deontic Qualification. The proposed scheme for UFO-B reveals other terms, such as State and Event. All of these terms are duly formalized in logical notation throughout this paper.

$$\begin{aligned}
 (a) \text{Agent} &\equiv (\text{CivilPerson} \sqcup \text{Organization}) \sqcap \exists \text{isActorOf}.\text{Behavior} \\
 (b) \text{Agent} &\sqsubseteq \exists \text{hasIntent}.\text{Intention} \\
 (c) \text{CivilPerson} &\equiv \exists \text{hasDocument}.\text{CPF} \\
 (d) \text{LegalPerson} &\equiv \exists \text{hasDocument}.\text{CNPJ} \sqcap \\
 &\quad \exists \text{hasCivilRepresentant}.\text{CivilPerson}
 \end{aligned}
 \tag{1}$$

An agent corresponds to a civil person or an organization that has done some behavior (DL equation 1a). In this circumstance, it is a necessary condition that an agent has an intention (a kind of mental state), either to realize the

<sup>4</sup>a doctrine in which special law derogates the general law.

behavior knowing the possible consequences (Malice) or when there is not criminal behavior intention (Fault) (DL equation 1b). While Civil Person instances have a national registry known as CPF (DL equation 1c), a Legal Person, a subtype of organization, has a national document known as CNPJ (DL equation 1d). A Civil Person specializes in Attributable Person, when the agent has at least 18 years (i.e. is an adult) and does not have any mental disorder; otherwise a civil person is said Unimputable (DL equations 2a,b). Another type of organization is the Society itself. Other particular types of agents are the active and passive agents: the former refers to someone whose behavior is assessed as a prohibited behavior by law, and the other is the one that had any property violated by the active agent. Hence, they configure disjoint concepts (DL equations 2c,d,e).

- (a)  $\text{UnimputablePerson} \equiv \text{CivilPerson} \sqcap (\exists \text{hasDisorder.MentalDisorder} \sqcup \exists \text{hasAge. (Teenager} \sqcup \text{Child} \sqcup \text{Elderly)})$
- (b)  $\text{UnimputablePerson} \sqsubseteq \neg \text{AttributablePerson}$
- (c)  $\text{ActivePerson} \equiv \text{AttributablePerson} \sqcap \exists \text{isActorOf. TypifiedConduct}$
- (d)  $\text{PassivePerson} \equiv (\text{CivilPerson} \sqcup \text{Organization} \sqcup \text{Society}) \sqcap \exists \text{hasObjectProperty. (LegalObject} \sqcup \text{MaterialObject)}$
- (e)  $\text{ActivePerson} \sqsubseteq \neg \text{PassivePerson}$

Even a criminal behavior addressed by an Action or Omission, only the civil agent itself may be the crime active subject. According to Article 173 of the Brazilian Federal Constitution, the legal person cannot be an active agent, unless the individual who acted in its name is discovered.

Conduct is defined by having an Event, i.e., an agent Action or Omission leading to a conscious purpose. Conducts are the kernel of the law, and through which are associated other elements, like an offender agent, an action, possibly a passive agent, a place, a time, a frequency, an object and/or instrument for the crime, and other extras and necessary circumstances. Notably, no criminal conduct exists when the behavior is involuntary, as in reflex actions, overwhelming physical coercion or unconscious states such as sleepwalking and hypnosis (DL Equation 3a,b,c). Conduct is, therefore, a purely voluntary behavior (DL Equation 3d). Events are actions or omissions, which (according to UFO-B) have an initial state and a final state (in the legal context, a causal link). A state in UFO-B defines situations which hold state of affairs (DL Equation 3 (e,f)).

- (a)  $\text{Comportment} \equiv (\text{Voluntary} \sqcup \text{Involuntary}) \sqcap \exists \text{hasActor. Agent}$
- (b)  $\text{Involuntary} \equiv \text{Comportment} \sqcap \{\{\text{Duress, Hypnosis, Reflection, Sleepwalking}\}\}$
- (c)  $\text{Voluntary} \sqsubseteq \neg \text{Involuntary}$
- (d)  $\text{Conduct} \equiv \text{Voluntary} \sqcap \exists \text{hasEvent. Event}$
- (e)  $\text{Event} \equiv (\text{Action} \sqcup \text{Omission}) \sqcap \exists \text{preState. State} \sqcap \exists \text{posState. State}$
- (f)  $\text{State} \equiv \exists \text{holds. T}$

The Qualifications are usually applied to the behavior to set them as a permitted, prohibited or mandatory conduct. Therefore, the rules addressed by the legal system provide the foundation required qualifying any behavior. From the logical

operators  $O$  (Obligation),  $Ph$  (Prohibition) and  $P$  (Permission), and assuming an arbitrary proposition  $\rho$ , we have the following logical equivalence:

$$O\rho \equiv Ph\neg\rho \equiv \neg P\neg\rho \quad (4)$$

Ferraz [16] conceptualizes this qualification as the functor of Legal Rules. Here, we consider only the prohibitive and permissive qualifications for the following reasons: (i) the vast majority of Brazilian legal norms focuses on these two types, and (ii) a mandatory norm could logically be interpreted according to these other qualifications. Particularly, from equation 4 it is inferred that if a conduct is prohibited, then it is not allowed to behave as such (equation 5).

$$Ph\rho \equiv \neg P\rho \quad (5)$$

Norm is a type of Document, which specializes in Articles and Principles. The class Article was specialized into Prohibitive and Permissive Article. Likewise, Conducts are seen as qualified generic situations that are prohibited (or permitted). We opted for a lower granularity in modeling articles (instead of law), as they define themselves the conduct to be checked and the punishment to be imposed; thus, it is not feasible to judge conduct by a law. When modeling a legal situation, it is expected that a reasoner can classify as a violation of a duly formalized article. This matching (Generic Case x Norms) is achieved by the logical relationship in DL equations 6.

- (a)  $\text{ProhibitiveArticle} \equiv \exists \text{prohibits. Prohibition} \sqcap \forall \text{prohibits. Prohibition}$
- (b)  $\text{Prohibition} \sqsubseteq \exists \text{isProhibitedBy. ProhibitiveArticle}$
- (c)  $\text{PermissiveArticle} \equiv \exists \text{permits. Permission} \sqcap \forall \text{permits. Permission}$
- (d)  $\text{Permission} \sqsubseteq \exists \text{isPermittedBy. PermissiveArticle}$
- (e)  $\text{prohibits} \equiv \text{isProhibitedBy}^-$
- (f)  $\text{permits} \equiv \text{isPermittedBy}^-$

As mentioned before, a Crime is a typical (prohibited by some norm), illicit (there is no circumstance that excludes unlawfulness, such as self-defense, state of necessity, or legal obligations) and a culpable behavior (done by an attributable agent) DL Equation 7. Besides Crime, the Brazilian Penal Law defines also the concept of Contravention. These are easily distinguished by the punishment imposed. Formally, Crime admits Arrest or Detention. The Contravention, in turn, allows only Simple Imprisonment and Fine (financial penalty).

- (a)  $\text{TypicalConduct} \equiv \text{Prohibition}$
- (b)  $\text{LicitConduct} \equiv \{\text{Necessity, LegalObligations, SelfDefense}\}$
- (c)  $\text{IllicitConduct} \sqsubseteq \neg \text{LicitConduct}$
- (d)  $\text{CulpableConduct} \equiv \exists \text{hasActor. AttributablePerson}$
- (e)  $\text{Crime} \equiv \text{TypicalConduct} \sqcap \text{IllicitConduct} \sqcap \text{CulpableConduct}$
- (f)  $\text{Crime} \equiv \exists \text{hasPunishment. (Arrest} \sqcup \text{Detention)}$
- (g)  $\text{Contravention} \sqsubseteq \exists \text{hasPunishment. (Fine} \sqcup \text{SimpleImprisonment)}$

## VII. ONTOPROPERTYCRIME: MAPPING THE CRIMES AGAINST PATRIMONY

Some criteria need to be considered in the development of ontologies, such as modularity, extensibility, minimal encoding and minimal ontological commitment. In order to

allow sharing and reuse between systems and the incorporation of new terms, Guarino [17] suggests a hierarchical construction, encompassing various levels of generality. Thus, as Top ontologies, we have inspired in LKIF and UFO-B, from which, it was built the domain ontology *OntoCrimeAlpha*, as discussed in the previous section. *OntoPropertyCrime*, in turn, is the application ontology to map the allowed and prohibited behaviors of the set of articles describing the crimes against property. Thus, the concepts, relationships, properties and axioms were built based on the domain model. Furthermore, it is worth emphasizing that the various types of crime can be formalized as other application ontologies.

*OntoPropertyCrime* defines 9 behaviors, all sub-concepts of *TypicalConduct*. All cases of property crime were mapped. As future work, the ontology can be extended to cover statute norms with mitigating and aggravating circumstances.

$$\begin{aligned}
(a) \text{Theft} &\equiv \exists \text{hasEvent} . (\text{Subtraction} \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\text{ChattelObject}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\text{ChattelObject})))) \\
(b) \text{Theft} &\sqsubseteq \exists \text{isProhibitedBy} . \text{Article155\_Law2848\_Year1940} \\
(c) \text{Article155\_Law2848\_Year1940} &\sqsubseteq \exists \text{hasPunishment} . \text{Fine} \\
(d) \text{Article155\_Law2848\_Year1940} &\sqsubseteq \\
&\quad \exists \text{hasPunishment} . \text{Imprisonment\_01\_04\_Years} \\
(e) \text{Robbery} &\equiv \exists \text{hasEvent} . (\text{Subtraction} \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\text{ChattelObject}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\text{ChattelObject})))) \\
&\quad \sqcap \exists \text{hasEvent} . ((\text{VerbalThreat} \sqcup \text{PhysicalDamage}) \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\text{Object}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\text{Object})))) \\
(f) \text{Robbery} &\sqsubseteq \exists \text{isProhibitedBy} . \text{Article157\_Law2848\_Year1940}
\end{aligned} \tag{8}$$

DL equations 8(a,b) define “Theft” as an atomic event, where there are: the action of “to Subtract”, a pre-state where an agent has a chattel, and a post state, where this object was violated, i.e., an agent took the object away. We also say that the conduct is prohibited by *Article155\_Law2848\_Year1940*<sup>5</sup>. DL equations 8(c,d) formalize the punishment for Theft. The other punishments were omitted for reasons of space. Note that “Robbery” (DL equations 8(e,f)) is a complex event: in addition to theft, there is either a verbal threat or a physical damage. In this circumstance, the injured object may be abstract (the agents honor) or concrete (the agents body).

$$\begin{aligned}
(a) \text{RobberyWithDeath} &\equiv \exists \text{hasEvent} . (\text{Subtraction} \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\text{ChattelObject}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\text{ChattelObject})))) \\
&\quad \sqcap \exists \text{hasEvent} . (\text{PhysicalDamage} \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\{\text{Life}\}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\{\text{Life}\}) \\
&\quad \sqcap \exists \text{hasIntention} . (\{\text{Theft}\}))) \\
(b) \text{RobberyWithDeath} &\sqsubseteq \\
&\quad \exists \text{isProhibitedBy} . \text{Article157\_3\_Law2848\_Year1940}
\end{aligned} \tag{9}$$

For the “RobberyWithDeath” (DL equations 9), the physical damage is done against the agent’s life. What sets this crime from “Homicide” (DL equations 10), it is that in the first case, the intention of the active agent was to steal, but for this, it was necessary to reap the agent’s life. Although the crime of homicide is in the criminal code, it is not a property crime.

<sup>5</sup>due reference questions, the nomenclature of these norms is formed by their code, the law of which it is part of, and the respective year

$$\begin{aligned}
(a) \text{Homicide} &\equiv \exists \text{hasEvent} . (\text{PhysicalDamage} \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\{\text{Life}\}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\{\text{Life}\})))) \\
(b) \text{Homicide} &\sqsubseteq \exists \text{isProhibitedBy} . \text{Article121\_Law2848\_Year1940}
\end{aligned} \tag{10}$$

In “Extortion” (DL equations 11(a,b)), two characteristics must be present: there is a threat or physical harm, with intention to obtain some kind of economic advantage.

$$\begin{aligned}
(a) \text{Extortion} &\equiv \exists \text{hasEvent} . ((\text{VerbalThreat} \sqcup \text{PhysicalDamage}) \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\text{Object}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\text{Object}) \\
&\quad \sqcap \exists \text{hasIntention} . (\{\text{EconomicAdvantage}\}))) \\
(b) \text{Extortion} &\sqsubseteq \exists \text{isProhibitedBy} . \text{Article158\_Law2848\_Year1940}
\end{aligned} \tag{11}$$

Finally, the equations 12(a,b,c,d) define the crimes of “Damage” and “Misappropriation”. While the former does not specify the type of object, the second emphasizes that it is a chattel.

$$\begin{aligned}
(a) \text{Damage} &\equiv \exists \text{hasEvent} . ((\text{Destroy} \sqcap \text{Deteriorate}) \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\text{Object}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\text{Object})))) \\
(b) \text{Damage} &\sqsubseteq \exists \text{isProhibitedBy} . \text{Article163\_Law2848\_Year1940} \\
(c) \text{Misappropriation} &\equiv \exists \text{hasEvent} . (\text{TakeOwnership} \sqcap \\
&\quad \exists \text{preState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{hasProperty} . (\text{ChattelObject}))) \\
&\quad \sqcap \exists \text{posState} (\exists \text{holds} (\text{Agent} \sqcap \exists \text{violates} . (\text{ChattelObject})))) \\
(d) \text{Misappropriation} &\sqsubseteq \\
&\quad \exists \text{isProhibitedBy} . \text{Article168\_Law2848\_Year1940}
\end{aligned} \tag{12}$$

## VIII. SOME REMARKS AND A CASE STUDY

In addition to developing the conceptual model, carrying out the assessment of concepts, axioms, properties, and relationships (such as the taxonomic structure) is an equally important and necessary task to keep a faithful model w.r.t. domain. At some extent, the *Methontology* already helps to preserve some essential features such as minimal ontological commitment and the ontology evolution. Moreover, through the *Hermit reasoner*<sup>6</sup>, it was possible to check these ontologies for possible inconsistencies, such as disjoint concepts with instances in common.

Furthermore, through the reasoner, it was possible to infer some new relations of subsumption, which are not explicit in the legislation. “RobberyWithDeath” was classified as a subtype of “Homicide” and “Robbery”. The latter was further classified as a subtype of “Theft”, which in fact is consistent with reality.

An interesting case to evaluate these ontologies is what happens at the movie *Ghost*<sup>7</sup>. *At the time, after going to the cinema, Sam and Molly decide to walk home. Then:*

*Ex1: Willie tackles Sam on the street and asks for his wallet with some verbal threats. In the dynamics of the situation, Sam dies, struck by a firearm.*

**Concept Instances:** *willie, sam: Agent, willie: Adult, willieConduct: Conduct, takeWallet: Subtraction, gunShoot: PhysicalDamage, wallet: ChattelObject.*

<sup>6</sup><http://www.hermit-reasoner.com/>

<sup>7</sup>Bruce Joel Rubin and Jerry Zucker.(1990)

**Relation Instances:** *willieConduct hasActor willie, willieConduct hasEvent gunShoot, willieConduct hasEvent takeWallet, takeWallet hasPreState (sam and hasProperty wallet), takeWallet hasPosState (willie and violates(wallet)), gunShoot hasPreState (sam and hasProperty {Life}), gunShoot hasPosState (willie and violates{Life})*.

For the study case, the instances are defined above. What defines the crimes are the behaviors. In the case, we do not add the willie intention, since as the movie goes on, it is suggested that his intention was not to steal. Therefore, the subtraction only served to hide the real crime. Thus, reasoning through the Hermit 1.3.8, available in Protégé 4.2.0 (Build 295), the following classifications were performed:

**Inferred:** *willie: ActivePerson, willie: AttributablePerson, sam: PassivePerson, willieConduct: Homicide, willieConduct: Robbery, willieConduct: TypicalConduct, willieConduct: CulpableConduct, willieConduct isProhibitedBy Article121\_Law2848\_Year1940, willieConduct isProhibitedBy Article157\_Law2848\_Year1940.*

Adding that willie intended to steal and, therefore, there was no legal excuse for his action, the following classifications would be deducted:

**Inferred:** *willieConduct: RobberyWithDeath, willieConduct: TypicalConduct, willieConduct: CulpableConduct, willieConduct: Crime, willieConduct isProhibitedBy Article157\_3\_Law2848\_Year1940.*

## IX. CONCLUSION AND FUTURE WORKS

After the assessment, the conceptual models were quite promising. The results so far were accompanied by experts of the criminal law area. Especially, legal hermeneutics professors have been collaborating with interpretation of codes and legal regulations, to proceed with the conceptual formalization.

The formalization of legal documents in a machine-readable and unambiguous way is not limited to academic interest. In fact, many governmental initiatives are searching to create a free access to legislation online. Nevertheless, the online availability of legal documents does not solve the practical problems of citizens and businesses: an approach to model the knowledge and interpretation from legal documents, queries or laws is essential to improve the outcomes. As a future proposal, we are analyzing the adequacy of these ontologies with other fragments of UFO-B, and then, with the entities in the UFO-A and UFO-C. This will allow a wider range of possibilities to model other criminal types arranged in the Brazilian penal code.

Finally, in a parallel work, we are investigating the ontological suitability for other legal tasks such as meta-reasoning to resolve conflicts when a conduct violates disparate norms. As a future contribution, we envision the creation of e-government systems, able to help ordinary citizens, to democratize, in

the full sense of the word, access and understanding of the Brazilian legal system.

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