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REQUIREMENTS ENGINEERING IN THE DEVELOPMENT OF ONTOLOGY ENGINEERING IN BIOMEDICAL ENGINEERING

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Abstract: In recent years, we have noticed a growth in interest in the application of ontologies, especially in Biomedical Engineering, where the use of ontology comes from, and the objective of this work is to present a methodology for a survey of requirements in the development of ontology, where when we think about the development of an ontology whose purpose is the representation of knowledge for the web, that is, the creation of content for the semantic web in which Methontology stands out, being a framework that, among other functionalities, supports the construction of ontologies at the level of the knowledge and present some works aimed at the construction of ontologies and the use of ontology provides many advantages, making possible a better understanding in a certain area of knowledge, enabling the interoperability of systems, enabling the sharing and reuse of information, are some of the main benefits of using ontologies.
Keywords: Requirements Engineering, Ontology Engineering, Ontology, OWL.

INTRODUCTION

In recent years, we have noticed a growing interest in the application of ontologies to solve modeling and classification problems in several areas. Requirements engineering is an area that includes 4 (four) sub-processes related at a high level. These sub-processes are: 1 - evaluating whether the system will be useful for the company (feasibility study), 2 - obtaining the requirements (requirements elicitation), 3 - converting these requirements into some standard form (specification), 4 - checking whether the requirements really define the system that the customer wants (validation) (SOMMERVILLE, 2017).

Currently, ontologies are used in the field of Engineering and Knowledge Management, focusing on collaboration between people and/or worldviews, interoperability/integration of information sources, instruction as a source of reference and modeling of knowledge elements (RAUTENBERG, S. et al., 2008).

According to Gruber (1993) "an ontology is a formal and explicit specification of a shared conceptualization". In this definition, "conceptualization" means an abstract model. The word "explicit" indicates that the elements of the ontology are clearly defined and, finally, the word "formal" expresses that the ontology must be machine processable. (FENSEL, 2001).

For Gruninger (1995), an ontology is a specification of a conceptualization: a description of concepts and relationships that exist in a domain of interest. Basically, an ontology consists of these concepts and relations, and their definitions, properties and restrictions that are described in the form of axioms.

On the *website* of the Ontology Research Seminar in Brazil (ONTOBRAS 2022), we have the following definition of ontology:

> "Ontology is an interdisciplinary field that studies concepts and theories that support the construction of shared conceptualizations of specific domains such as: Computer Science, Information Science, Philosophy, Artificial Intelligence, Linguistics, Knowledge Management, Semantic *Web, among others"* (ONTOBRAS, 2022).

On the W3C *website* it informs that "Ontologies are important tools and valuable instruments to organize the data of a domain" (W3C, 2022)

GENERAL PURPOSE

The general objective of this work is to present a methodology for a survey of requirements in the development of ontology for the Ontology Engineer (EO).

REQUIREMENTS

Requirements describe the behavior of a system and have three purposes (PFLEGER, 2001):

- Requirements allow developers to explain their understanding of how the customer would like the system to work.
- Requirements tell software designers what functions and features the system must have.
- The requirements guide the test team to demonstrate and convince the customer that the system being delivered is indeed what was ordered.

According to Sommerville (2003) "the term *stakeholder* is used to refer to any person who has some direct or indirect influence on the requirements of the system". Among the *stakeholders* are:

- End users who will interact with the system and all personnel in an organization who will be affected by it;
- Engineers who are developing the system or maintaining other related systems;
- Business managers;
- Experts in the application domain;
- The company's top management, who is paying the system;
- Requirements analyst;
- System operator;
- People who will prepare entries for the system;
- People who will use the outputs or products of the system;
- Manager of the people who will operate, prepare the input, use the output of the system.

CLASSIFICATION OF REQUIREMENT

Classification of requirements assists in identifying and describing requirements. Requirements are classified as functional or non-functional or as domain requirements:

- **Functional Requirements (RF):** "are statements of functions that the system must provide, how the system must react to specific inputs and how it must behave in certain situations. In some cases, functional requirements may also explicitly state what the system must not do" (SOMERVILLE, 2003). "A functional requirement describes an interaction between the system and the environment. The functional requirements describe how the system must behave from a certain stimulus" (PFLEEGER, 2001).
- **Non-Functional Requirements (NFR):** "These are restrictions on the services or functions offered by the system. Among them are time restrictions, restrictions on the development process, standards, among others" (SOMMERVILLE, 2003). According to Pfleeger (2001) "a non-functional requirement describes a system constraint that limits the choices in building a solution to the problem". Therefore, it is important to pay special attention to non-functional requirements.
- **Domain Requirements (RD):** "These are requirements that originate from the system's application domain and that reflect characteristics of that domain. They can be functional or non-functional requirements" (SOMMERVILLE, 2003).

Another important classification to be made is regarding the importance of each requirement Pfleeger (2001) suggests classifying them into three categories:

- Essential requirements;

- Desirable but not necessary requirements;
- Requirements possible, but can be discarded.

From an evolutionary perspective, Sommerville (2003) classifies requirements as:

- **Permanent Requirements:** relatively stable requirements, which derive from the main activity of the organization and which are directly related to the domain of the system;
- **Volatile Requirements:** requirements that are likely to change during system development or after the system is in operation;
- R**equirements:** requirements that change because of changes in the environment in which the organization is operating;
- **Emerging Requirements:** Requirements that arise as the customer's understanding of the system develops during system development. The design process can reveal new emerging requirements;
- R**equirements:** requirements that result from using the computing system. This system can modify the organization's processes and create new ways of working, which can generate new system requirements.

Table 1 presents a simple summary of each classification.

ONTOLOGY ENGINEERING (OE)

Ontology Engineering (EO) was designed to deal with issues that were not addressed by Knowledge Engineering (KE). Bonini (2019), presents three reasons as fundamental. The first refers to the need to deeply understand the basic concepts to allow knowledge sharing. Second is the insertion of the concept of ontology, which enables the explicit and unequivocal representation of knowledge. The third is the scarcity of technologies capable of dealing with the increase in knowledge generated, which was solved with the implementation of tools capable of dealing with different forms of representation (BONINI, 2019).

According to the World Wide Web (W3C) (W3C, 2018), ontology is composed of the definition of terms used in the description and representation of an area of knowledge, as well as providing descriptions for the following types of concepts:

- Classes – in the various domains of interest;
- Relationships between these classes;
- Properties (attributes) that these classes must have.

One of the goals of the ontology is to capture the knowledge of a domain in a generic way and to promote a shared understanding so that it can become a domain ontology. In general, whatever the domain, the complexity involved in building ontologies is great.

Ontology engineering must have some criteria to guarantee its quality. In the literature we can find several criteria that are considered in the construction and evaluation of an ontology. Table 2 presents some of the most important criteria according to Oliveira; Werneck (2003).

The ontology representation language is independent of data types and programming language, and must involve the following primitives: concepts, functions, axioms, instances and relations.

Sanches, (2017) informs that ontology can be classified into 5 (five) categories:

- **Generic Ontologies:** They are considered "general" ontologies. They describe broader concepts, such as

Summary of Requirements Classification	
Functional Requirements	They are everything that is needed for the *software to* work.
Non-Functional Requirements	Everything that does not interfere with the operation or is not necessary for the software to work, for example, the *Browser* (browser) in a *Web system,* such as *Facebook,* regardless of the *Browser,* the user opens *Facebook.*
Domain Requirement	They are specific is a characteristic to the domain of the system.

Table 1: Summary About Classification of Requirements.

Criterion	Description
Clarity	Effectively communicate the intended meaning of defined terms through formalisms. Definitions must be objective, complete, independent of social or computational context, and documented in natural language.
Coherence / Consistency	An ontology must be coherent, it must infer sentences consistent with the definitions. If a sentence inferred from axioms contradicts an informally given definition or example, then the ontology is incoherent. Definitions must be consistent with the real world and with each other.
Extensibility	An ontology must allow new terms to be defined without changing existing terms.
Minimum Implementation Commitments	Conceptualization must be specified at the knowledge level, without relying on particular representation or encoding technology.
Ontological Commitments Minimum	An ontology must require the minimum ontological commitment sufficient to support the desired knowledge sharing activities.
Support	Support the development of large applications
Generality	Be able to be shared between different activities such as design and analysis.
Conciseness	Contain only necessary information with concise definitions, avoiding formal and informal redundancies.
Completeness	Ensuring the completeness of the formal definition and the informal definition
Robustness	Be robust so that small changes do not affect the set of definitions already evaluated

Table 2: Criteria for Construction and Evaluation of Ontology (OLIVEIRA; WERNECK 2003).

Process	Description
Specification	Identify the purpose and scope of the ontology. Purpose answers the question "why is the ontology built?", while scope answers the questions what are the intended uses and users of the ontology?"
Conceptualization	Describe, in a conceptual model, the ontology to be built, according to the specifications found in the previous stage. It must be noted that the conceptual model of an ontology can be built using formal and informal tools. Such a model consists of domain concepts, the relationships between the concepts, and the properties of the concepts.
Formalization	Transform the conceptual description into a formal model. In this phase, concepts are defined through axioms that restrict the possible interpretations of their meaning and also organized hierarchically through structural relations, such as "is-a" or "part-of".
Implementation	Implement the formalized ontology in a knowledge representation language.
Maintenance	Update and correct the developed ontology, according to the emergence of new requirements.

Table 3: Ontology Construction Processes.

elements of nature, space, time, things, states, events, processes or actions, regardless of a specific problem or particular domain.

- **Domain Ontologies:** They describe concepts and vocabularies related to particular domains, such as medicine or computing, for example. This is the most common type of ontology, usually built to represent a “micro-world”.
- **Task Ontologies:** They describe generic tasks or activities that can contribute to solving problems, regardless of the domain in which they occur, for example, sales processes or diagnosis. Its main motivation is to facilitate the integration of task and domain knowledge in a more uniform and consistent approach, based on the use of ontologies.
- **Application Ontologies:** Describe concepts that depend both on a particular domain and on a specific task. They must be specializations of the terms of the corresponding domain and task ontologies. These concepts usually correspond to rules applied to domain entities while performing a certain task.
- **Representation Ontologies:** Explain the conceptualizations that underlie knowledge representation formalisms, seeking to clarify the ontological commitments embedded in these formalisms.

Ontology development requires considerable engineering effort, discipline and rigor, where design principles, development activities and processes, support technologies and systemic methodologies must be employed. In this context, Ontology Engineering emerges, concerned with the set of activities, the ontology development process, the ontology life cycle, the methods and methodologies to develop ontologies and the tools and languages to support the construction of ontologies (RAUTENBERG, S. et al., 2008).

EO is based on *Software Engineering*. Therefore, in the ontology construction process, specification, conceptualization, formalization, implementation and maintenance activities are usually accepted. For each of these activities there are tasks to be performed, as shown in Table 3.

For Rautenberg, S. et al., (2008) other activities during the life cycle of an ontology must be scored:

- **Knowledge Acquisition:** Acquiring knowledge about a domain through knowledge elicitation techniques with domain experts or referring to the relevant bibliography. Several techniques can be used, such as brainstorming, interviews, questionnaires, text analysis and inductive techniques.
- **Evaluation:** Technically judge the quality of the ontology through:
- **Technical Assessment:** judging the ontology and documentation against a frame of reference. There are two activities involved:

  a) Verification, which guarantees the correctness of the ontology according to the accepted understanding of the domain in specialized knowledge sources;

  b) Validation, which guarantees that the ontology corresponds to its supposed purpose, according to the requirements specification documents.
- **User evaluation:** judging the ontology from the user’s point of view, in relation

to its usability and usefulness; and from the point of view of (re)use in other applications in accordance with their documentation.

- **Documentation:** reporting what, how and why was done. Documentation associated with the terms present in the ontology is very important, not only to improve the clarity of the ontology, but also to facilitate maintenance, use and reuse.

According to Rautenberg, S. et al., (2008) points out that the set of activities listed above may not be fully contemplated in a methodology for developing ontologies. There are methodologies that are used in specific activities in Ontology Engineering. That is why Rautenberg informs that a combination of methodologies becomes relevant in the development of ontologies.

In Table 4, other components of an ontology according to Sanches (2017) are observed:

According to Sanches (2017), there are many methodologies for creating ontologies. They are intended to systematize construction and manipulation. However, the two methodologies described below are those that are currently the most technically used by the scientific community, namely:

- ***Methontology:*** It is based on the construction of ontology from the knowledge of a domain. Its main activities are requirements specification, conceptualization of the knowledge domain, formalization of the conceptual model in a formal language, implementation of a formal model and maintenance of implemented ontologies. This methodology also has support activities performed during the ontology construction process, that is, knowledge acquisition, integration, evaluation, documentation and configuration management. Figure 1 illustrates these stages of the *Methontology* (MARAFFI, 2004).

Table 5 presents the description of the 9 (nine) steps of the *Methonology methodology*, as it presents the desired characteristics with regard to the representation and detailing for the creation of ontology.

- ***Enterprise:*** It is based on the four phases seen in Figure 2, namely, purpose identification, scope identification, formalization and formal documentation. The identification of the purpose determines the level of formality that the ontology must be described; In scope identification, a specification is produced according to the domain that the ontology needs to represent; Formalization is the creation of the code, formal definitions and axioms related to the ontology; Formal documentation is the phase where the ontology will be documented and the scope identification and formalization phases can be reviewed (MORAIS; AMBROSIO, 2007).

There are other ontology-oriented methodologies. These being: *Gruninger and Fox* methodology; *Uscold and King method; Kactus method; Method 101; SENSUS ontology; Ontobio; Medical Subject Headings (MeSH); Gene Ontology (GO); Open Biomedical Ontologies (OBO); Foundational Model of Anatomy (FMA), SNOMED Clinical Terms (SNOMED CT), On-To-Knowledge, Systematic Approach for Building Ontologies (SABIO)*, among others.

WEB ONTOLOGY LANGUAGE (OWL)

According to Sanches (2017), OWL is recommended by the W3C consortium as the main language for building ontologies. This language's main objective is to meet the application needs of the Semantic *Web* and be

Components of an Ontology	
types	**Description**
Individuals	Instances or objects; Classes: sets (or collections), types of objects or types of things.
Attributes	Aspects, properties, characteristics or parameters that objects and classes can assume.
Relations	Relationships that can be established between objects or classes.
Rules	Implications that describe the logical inferences that can be drawn from a given assertion.
Axioms	Ideas that the ontology describes in its application domain
Events	Changes to attributes or relationships to be established between objects or classes.

Table 4: Other Components of an Ontology (SANCHES, 2017).

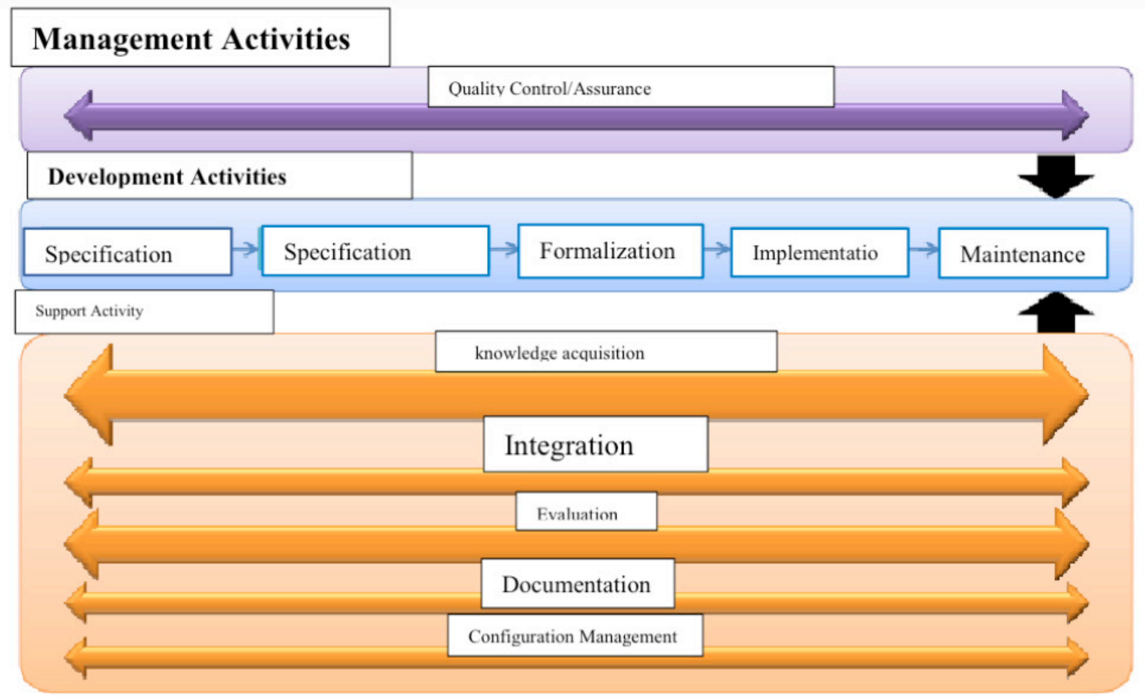

Figure 1 : Methontology steps.

Description of the 9 Steps of *Methonology.*	
Specification	It aims at the elaboration of a document, meetings, using natural language, containing information such as: the main objective of the ontology and its other purposes.
Knowledge Acquisition	Searches for possible sources of knowledge, such as interviews with domain experts, consulting books, articles, manuals, standards, existing ontologies, among others. Despite being an initial stage, it must be present in all others.
Conceptualization	Considered as the main phase of this methodology. It deals with the structuring of the domain of knowledge, in a conceptual model. It is based on the vocabulary acquired from the previous phases, aiming at describing the problems faced and their possible solutions.
Formalization	The conceptual model created in the previous stage is transformed into a formal model, that is, it is represented through a formal language, using a specific *software* / application such as *Protégé.*
Integration	It aims to integrate the ontology that is being built with other existing ones, such as on the SWOOGLE *Protégé site,* OBO, as well as other ontology bases known to carry out the integration of the built ontology. Thus, involving the search for ontologies that best fit the conceptualization used.
Implementation	*Protégé* software/application can be used, which generates the OWL file.
Evaluation	It deals with the evaluation itself of the developed ontology and must consider the verification and validation processes.
Documentation	Helps in possible maintenance, and facilitates one of its advantages, reuse. It is composed of some elements, such as documents of: requirements specification, reached after the ontology specification; knowledge acquisition; conceptual model, obtained after conceptualization; formalization and evaluation, such as the OWL model, vocabulary worksheet, block diagrams and flowcharts developed from conceptualization to evaluation.
Maintenance	They constitute the changes, when necessary, for possible improvements or corrections, and may also be made available on *sites,* such as *Protégé* and *SWOOGLE,* so that other researchers contribute with more information.

Table 5: Description of the 9 Steps of the *Methonology methodology.*

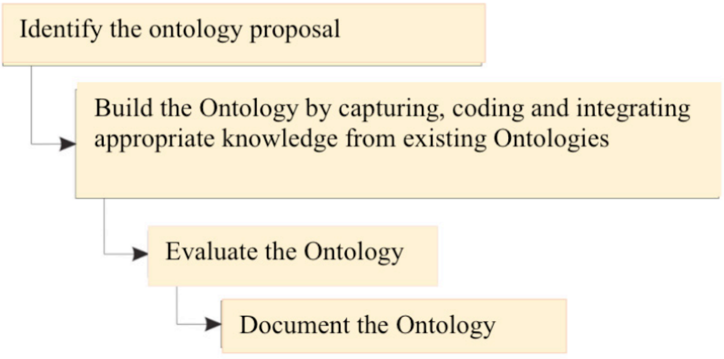

Figure 2: Methodology *Enterprise* (MORAIS; AMBRÓSIO, 2007).

effectively used by applications that need to process the information content, and not just present the visualization of information.

The OWL language was and is designed to provide an ontology language that can be used to describe, in a natural way, classes and relationships in documents and *web applications.* The basic elements for building an OWL ontology are classes, instances of classes (individuals), properties and relationships between classes and instances (SANCHES, 2017).

Besides, according to Sanches (2017), the OWL has three incremental sub-languages designed to be used by different communities of implementers and users:

- **OWL Lite:** is a sub-language of OWL DL *(description logics)* that uses only some features of the OWL language and has more limitations than OWL DL or OWL Full;
- **OWL DL:** is used by users who want maximum expressiveness, with computational completeness (all conclusions are guaranteed to be computable) and decidability (all computations will finish in a finite time). It includes all OWL language constructs, but these constructs can only be used under certain restrictions. The acronym DL corresponds to descriptive logic, an area of research that studies a particular fragment of first-order logic;
- **OWL Full:** is used by users who want maximum expressiveness and syntactic independence from the *Resource Description Framework* (RDF), without any computational guarantees. OWL *Full* and OWL DL support the same set of OWL language constructs, albeit with slightly different restrictions. While OWL DL imposes restrictions on the use of RDF and requires disjunction of classes, properties, individuals and data values, OWL *Full* allows mixing OWL with RDF *Schema* and does not require disjunction of classes, properties, individuals and data values. That is, a class can be both a class and an individual.

The *Resource Description Framework* (RDF) aims to define a metadata representation mechanism to describe resources not linked to a specific application domain. The RDF description structure is composed of three types of objects: resources, properties and triples. A resource is what will be described by an RDF expression. Every resource is identified by a URI (*Uniform Resource Identifier,* including the *Uniform Resource Locator* - URL). A property is any characteristic used to describe a resource.

METHODOLOGY

The research methodology was the bibliographic one where we can highlight the *Methontology,* it is a *framework* that, among other features, supports the construction of ontologies at the knowledge level. Unlike the others, this methodology describes the identification of the ontology development process by dividing it into types of activities to be developed, describes the life cycle of an ontology, from the evolution of prototypes as well as specific techniques for each activity performed observed in Table 6.

When we think about the development of an ontology whose purpose is the representation of knowledge for the *web,* that is, the creation of content for the semantic *web,* where there are many researches using ontology as the main focus, below will be some researches using ontology in the context of health, carried out by researchers in order to demonstrate how ontology is being used within Biomedical Engineering, with some

Ontology Development Processes by *Methontology*	
Activity	**Description**
1. Project management activities	1.1 Planning: identification of tasks to be performed, how these tasks must be organized, how much time and what resources they must consume until they are completed. This activity is essential when intending to reuse existing ontologies; 1.2 Control: activity that ensures that the tasks planned in the previous phase are carried out 1.3 Quality assurance: activity that ensures that the products resulting from activities (ontology, *software,* documentation) are satisfactory;
2. Development-oriented activities	2.1 Specification: activities that define why the ontology will be built, what use will be made of it and who will be its end users; 2.2 Conceptualization: ontology knowledge domain structuring activities using knowledge-level meaning models; 2.3 Formalization: activities to transform the conceptual model of the previous activity into a formal or semi-computable model; 2.4 Implementation: construction activities of computable models in a computational language; 2.5 Maintenance: ontology update and correction activities.
3. Support activities performed in parallel with development	3.1 Acquisition of knowledge: activities to acquire knowledge about a given domain; 3.2 Evaluation: activities of technical judgment of ontologies, associated software environments and documentation produced, using *frames* of reference; 3.3 Integration: essential activities when there is reuse of existing ontologies; 3.4 Documentation: clear and exhaustive detailing activities of the development phases.

Table 6: Identification of Ontology Development Processes by *Methontology.*

works such as:

- Lunardi et al (2018), developed a Probabilistic Ontological Model to Assist People with Cognitive Decline, providing reminders to an elderly person while carrying out their daily activities, it is a user support activity.
- Sanches (2017), developed an ontology in the treatment of Breast Neoplasia (NM) the ON-TO-BREAST: NM, this model is a tool to assist specialists and students in the health area in the treatment of breast cancer. The ontological model was created in the *Web On-tology Language* (OWL), its main advantage is the ease of expressing meanings and semantics and applicability in the process of information in an automated way. As it is a model applied to the medical field, ONTO-MANA-NM seeks to maintain compatibility with the Digital Imaging and Communications in Medicine (DICOM) and Health Level Seven International (HL7) standards, in order to preserve the interoperability of information of patients in hospital settings.
- Melo et al (2016), who developed the ONTO-MA-MA: Ontology for Teaching and Learning Students, describe the process of building an ontology, called ONTO-MAMA, to assist professionals and students in the medical field specialized in oncology. The ontology developed will allow the user to obtain knowledge more quickly and completely, as it will provide both conceptual information, as well as images, videos and prototypes developed in a three-dimensional (3D) modeling environment.
- Mendonça and Almeida (2015), developed ONTOFORINFOSCIENCE: A Detailed Methodology for the Construction of Ontologies and their Application in the Domain of Biomedicine, the objective of this new methodology is to help specialists in Knowledge Organization to overcome problems related to technical jargon and logical and philosophies in the development of ontologies. In order to identify these problems, OntoForInfoScience was created by information scientists during the development of HEMONTO, a domain ontology about human blood components for hematology and hemotherapy.
- Sabino and Heinzle (2015) developed a tool for ontology construction from unstructured data, in which the work uses the OWL tag specification of the *Protégé tool* to create an ontology adapted from Curilem (2002). The ontology created was edited in the *Protégé tool,* thus demonstrating that it is compatible with the OWL *tag standard used by it.*
- Elisa, Pickler, Ferneda (2014) developed a method for using ontologies in automatic indexing. The work presents technical guidelines for the construction and use of ontologies in the automatic indexing process through examples. It is concluded that the use of ontologies in the indexing process allows not only to add new resources to the indexing process, but also to think of new and advanced functionalities in an information retrieval system.
- Neto (2013), developed ONTOLIME: Medical Images Description Ontology Model, which consists of building an ontology model of medical images

taking into account the images (human and other animals) from the terminology of the health area and of information referring to images collected on didactic sites, aiming at accessing and retrieving image information in the health area, with greater added value.

- Souza, Falbo, Vijaykumar (2012), developed the use of ontologies in quality assurance and process improvement. The work presents an overview of the study of the art of ontologies and their use in quality assurance and *software process improvement.*
- Isac and Conci (2011) developed the use of ontologies for the manipulation of images related to breast cancer. The work presents a systematic study of applications that use ontologies as a tool for manipulating medical images related to breast cancer, describing the main characteristics of systems that use them.
- Klavdianos et al. (2011) developed an ontology of the anatomy of the female breast (ONTO--BREAST). The authors created an ontology of the anatomy of the breast in which the first stage of the project was the elaboration of the ontology for the description of the medical procedure of puncture of the breast with a fine needle and the construction of the virtual reality environment.
- Guizzardi et al. (2009), developed ontologies of foundation and conceptual modeling, the objective of this work is to present the group of the Nucleus of Studies in Conceptual Modeling and Ontologies (NEMO), organized as part of the program of international diffusion of research and education in ontologies of the *International Association on Ontologies and Applications* (IAOA), through its *International Outreach Subcommittee.*
- Freitas, Schulz, Moraes (2009), carried out a survey of current terminologies and ontologies in biology and medicine. The work presents a descriptive structure, compares the systems in terms of their architectural elements, expressiveness and coverage, in addition to analyzing the nature of the entities they denote. In particular, it examines the International Classification of Diseases (ICD), Medical Subject Headings (MeSH) Medical Headings, *Gene Ontology* (GO) Genetic Ontology, *Systematized Nomenclature of Medicine – Clinical Terms* (SNOMED – CT) Systematized Nomenclature of Medicine – Clinical Terms, *Generalized Architecture for Languages, Encyclopaedias and Nomenclatures (* openGALEN), Generalized Architecture for Languages, Encyclopedias and Nomenclatures, *Foundational Model of Anatomy* (FMA), *Unified Medical Language System* (UMLS) *Foundry* Workshop on Open Biomedical Ontologies. Unified Medical Language and *Open Biomedical Ontologies* (OBO) *Foundry Open Biomedical Ontologies* Workshop.
- Lichtenstein, Sigulem, D. Md (2008), created a health ontology with the *Protégé tool* in the OWL standard and described important concepts about the Protégé ontology editing and administration tool and the OWL standard (language and ontology for the *web*), which was the first “complete” semantic standard adopted by the WWW Consortium and the AI

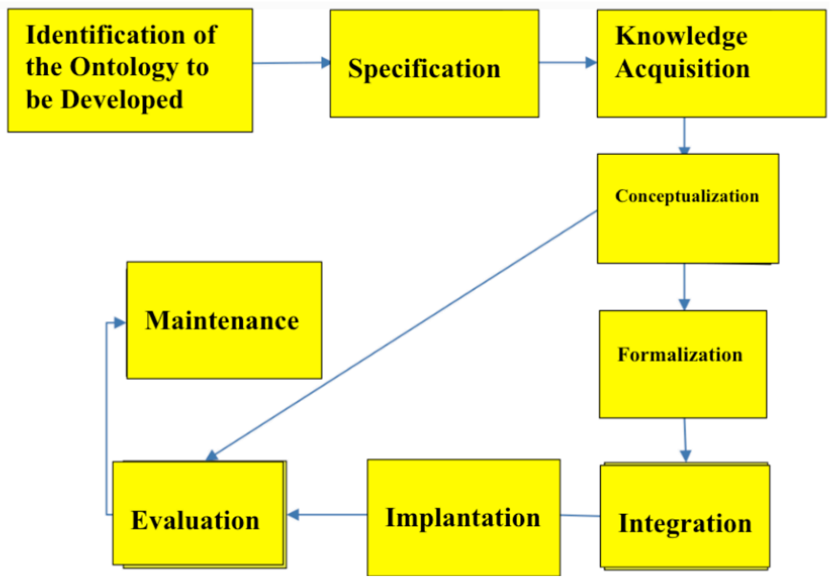

Figure 3: Block Diagram.

EO techniques		
Identification of the Ontology to be Developed	•	Analyze the ontology to be developed.
Specification	• •	Identify the scope of the ontology; Documentation
Knowledge Acquisition	• • • •	Knowledge of ontology; Search for an expert in the area; Search for existing ontology; All forms of knowledge.
Conceptualization	• •	Construction of the conceptual model; Develop diagrams (if needed)
Formalization	•	Choice of ontology development *software.*
Integration	•	Integrate the developed ontology with the existing one (if found in the knowledge acquisition phase).
Implantation	•	OWL.
Evaluation	• • •	Evaluation of the documentation generated in the conceptualization; Evaluation of the ontological model; OWL.
Maintenance	•	Alteration, improvement or corrections.

Table 7: Explanation of Ontology Development Phases by an EO.

and Health Informatics communities.

- Morais, Ambrósio (2007) carried out the study of Ontologies: concepts, uses, types, methodologies, tools and languages, with the aim of describing the ontology concepts, their main uses, types, development methodologies, specification tools and programming languages. representation.

In Figure 3 we have the block diagram showing the ontology development phases by an OE.

Table 7 presents the explanation of each phase of the block diagram in Figure 3.

CONCLUSION

The use of ontologies in Biomedical Engineering has grown on a large scale, and they have been applied in different domains. Domain specification, integration of knowledge bases, search in an information base (documents and *Internet*), are some of the applications. However, whatever the objective of the ontology, it will constitute a definition of the knowledge of the domain, through concepts and relations related to that domain.

The use of ontologies provides many advantages. Making possible a better understanding in a certain area of knowledge, enabling the interoperability of systems, enabling the sharing and reuse of information, are some of the main benefits in the use of ontologies.

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