MentalDisOnt: An ontology for describing different types of mental disorders.

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**Abstract**

Semantic descriptions of mental disorders, offered in a machine-understandable form, can provide useful information benefit in the diagnosis of disorders. In this paper, we explain the development process made to build mental disorder ontology, for describing different types of mental disorders. It could be used as a model for the development of other ontologies for developing a knowledge graph.

The terms of the MentalDisOnt ontology provide different types of information related to a mental disorder, which is reflected in distinct modules that constitute the ontology. Thus, it contains classes and properties for expressing information about disorders diagnosed till now, comorbidity, symptoms, age group, ICD codes, risk factors, and finally level of intensity of that particular disorder. The ontology development process has been carried out in close collaboration with a domain expert.

**Keywords**: Ontology, Mental Disorder, Disorders Ontology, Mental Health

1. **Introduction**

A mental disorder is characterized by a clinically significant disturbance in an individual’s cognition, emotional regulation, or behavior [1].  It is usually associated with suffering or damage in important areas of functioning. There are many different types of mental disorders. There are nearly300 mental disorders listed in the DSM-5 [2]. In 2019, about 970 million people around the world were living with a mental disorder, with anxiety and depressive disorders as the most common [3]. During the COVID-19 pandemic, these numbers increased even higher, with a 25% increase in the prevalence of mental disorders around the world [4]. Numerous studies have been conducted in the domain of mental disorders to define their symptoms, causes, and cures. Thus, to assist doctors and patients we will develop an ontology for providing a detailed description of a mental disorder. We have not found any other ontology that provides a detailed description of all the mental disorders but other existing ontology related to a single disorder will contribute significantly to our ontology.

The purpose of this paper is to present MentalDisOnt ontology. It includes terms to describe 1) Classification 2) comorbidity (disorders that can be present in a person at once) 3) symptoms 4) ICD code 5) risk factors 6) age group and 7) levels of intensity

The MentalDisOnt ontology has been implemented using OWL and Protégé [5] development environment. MentalDisOnt is in line with the classification and information of mental disorders provided in DSM-V [6] (Diagnostic and Statistical Manual of Mental Disorder). MentalDisOnt incorporates concepts given in several ontologies: Bipolar Disorder Ontology [7], which explains the main concepts related to bipolar disorder; Schizophrenia Ontology [8], which explains symptoms and types of schizophrenic disorders; Mental Disorder Classification Ontology [9], provides classification/types of mental disorder; Posttraumatic Stress Disorder Ontology [10], classifies PTSD according to causal approach; Sleep Domain Ontology [11], explain different types of sleep medicines; and Autism Spectrum Disorder Ontology [12], provides phenotype for diagnosis of the autism spectrum.

Apart from the interest in MentalDisOnt ontology in itself, the main contribution of MentalDisOnt ontology is as follows: 1) Reusability, its structure facilitates the task of developing other ontologies on different types of mental disorders and diseases. Information related to Mental Disorders that are described in this ontology could be replaced by information about any other disorder/disease; 2) Expressiveness of relation between different disorders, it incorporates a hierarchical classification of possible disorders and their relations with different factors that help in describing a mental disorder. Dealing with all this detailed description a fine-grained result could be provided for the questions related to mental disorders.

Finally, the use of MentalDisOnt ontology as the core element for the ontology-based system, developed for Smart Diagnosis, can bring several benefits. For example, the development of a Visual Query System (Expert System) will bring the following benefits to different types of users of this Mental Disorder Ontology:

* Mental health Professionals. Description of Mental Disorders will help mental health professionals in providing a diagnosis. It will speed up the process of diagnosing a mental disorder.
* Patients. This ontology will help patients with mental issues in understanding their mental conditions. It will also be able to provide an answer they might have related to different symptoms they might have noticed in themselves.

In the rest of this document, we present the first, distinct approaches that have been defined in the literature, related to the development of ontologies related to mental disorders: existing ontologies and ontology evaluation techniques. Then, we show some methodologies that have been proposed to adequately develop ontologies. Next, we illustrate the steps that we will follow to develop the MentalDisOnt ontology using the NeOn methodology [[13]](#_bookmark83) and the modules that constitute MentalDisOnt. We finish with some conclusions and future work.

1. **Related work**

In the specialized literature several ontologies related to mental disorder domain can be found. Those ontologies were defined with distinct purposes and therefore describe different types of information related to that specific area of domain. For example, Bipolar Disorder Ontology [7] describe fundamental concepts related to bipolar disorder. Fundamental elements of the core of Bipolar Disorder Ontology are two main classes: continuent, occurrent. Bipolar Ontology is based on Mental Function Ontology for the description of bipolar disorder. Disease Ontology [15] is a standardized ontology to describe human disease terms, phenotype characters and related medical vocabulary. The Disease Ontology semantically integrates disease and medical vocabularies through extensive cross mapping of DO terms to MeSH (Medical Subject Headings), ICD (International Classification of Diseases), NCI’s (National Cancer Institute) thesaurus, SNOMED (Systematized Nomenclature of Medicine Clinical Terms) and OMIM (Online Mendelian Inheritance in Man). The main classes of Disease Ontology are: Anatomy, Cell, chebi, disease, disease driver, evidence, food material, inheritance pattern, ncbitaxon, omim\_susceptibility, onset, phenotype, sequence, symptoms, and transmission process. Schizophrenia ontology [8] was explained in “Ontologies, Mental Disorders and Prototypes” [9] in the IACAP 2016 Proceedings Schizophrenia Ontology describe different concepts related to Schizophrenia disorder like types and symptoms. Mental Disorder Ontological classification [9] provide classification and definition of different mental disorders according to ICD [18] and NIH [19] respectively. Mental Function Ontology [20] describes the function of human mind. Its primitive classes are continuent and occurrent. Posttraumatic Stress Disorder Ontology [10]

1. **Design Methodologies**

The literature presents several methodologies for ontology development, such as On-To-Knowledge, Diligent, and NeOn. On-To-Knowledge proposes a structured approach consisting of five main steps. Firstly, a feasibility study is conducted to determine whether it is appropriate to begin developing the ontology. Secondly, the kickoff step specifies the requirements and develops a semi-formal ontology description. Thirdly, the refinement step formalizes and refines the semi-formal ontology description to obtain the target ontology. Fourthly, the evaluation step assesses the ontology, and finally, the application and evolution step involves the application and maintenance of the ontology in the target system. Although On-To-Knowledge recommends the reuse of ontologies if available during the kickoff step, it does not provide any specific guidelines for doing so. Furthermore, On-To-Knowledge does not address non-ontological resources or ontology design patterns.

Diligent proposes a distributed ontology development process consisting of five steps. The first step involves building an initial version of the ontology by various stakeholders such as domain experts, users, and knowledge and ontology engineers. The second step, local adaptation, involves users adapting the ontology for their specific purposes. In the third step, analysis, a control board analyzes the local versions to identify similarities and determine which changes and requests should be added to the next shared version of the ontology. The fourth step, revision, involves the control board revising the new version of the shared ontology. The final step, local update, enables users to update their local ontologies with information from the new version. However, Diligent does not provide detailed guidance on the activities that should be followed during the build step, and it does not include guidelines for using ontological or non-ontological resources in the development process.

NeOn offers a more complex methodology than the previous two approaches, describing nine possible scenarios that may arise during ontology development. NeOn also provides several ontology network life cycle models, including the Four phase model, which consists of initiation, design, implementation, and maintenance. NeOn emphasizes the importance of reusing and re-engineering both ontological and non-ontological knowledge resources. The methodology provides detailed guidance on how to perform each activity in each phase of the ontology development process, as well as recommendations for tools and techniques to support each step. Additionally, NeOn includes further versions of the basic model, such as the Five-phase model and the Six-phase + Merging model, which include additional phases such as reuse, reengineering, and merging to accommodate a range of paths to ontology development.

1. **Development of MentalDisOnt Ontology**

In order to develop the MentalDistOnt ontology we selected the NeOn methodology. In our opinion, NeOn beats the other methodologies in these two aspects: on the one hand, the variety of scenarios that it takes into account, which results in a more flexible methodology, and on the other hand, the great detail in the description of the activities that need to be carried out when building the ontology. Furthermore, due to the requirements of MentalDisOnt, which include reuse of ontological and no-ontological resources, re-engineering, merging, aligning with domain ontologies, implementation and evaluation among others, its development process fits with the Six-Phase + Merging Phase Waterfall Ontology Network Life Cycle Model. In figure 1 the phases of the aforementioned life cycle model along with scenarios, activities and modules of the MentalDisOnt ontology involved in each scenario are indicated. These modules and their purpose are explained in section 5. The different phases of the life cycle model are explained below.

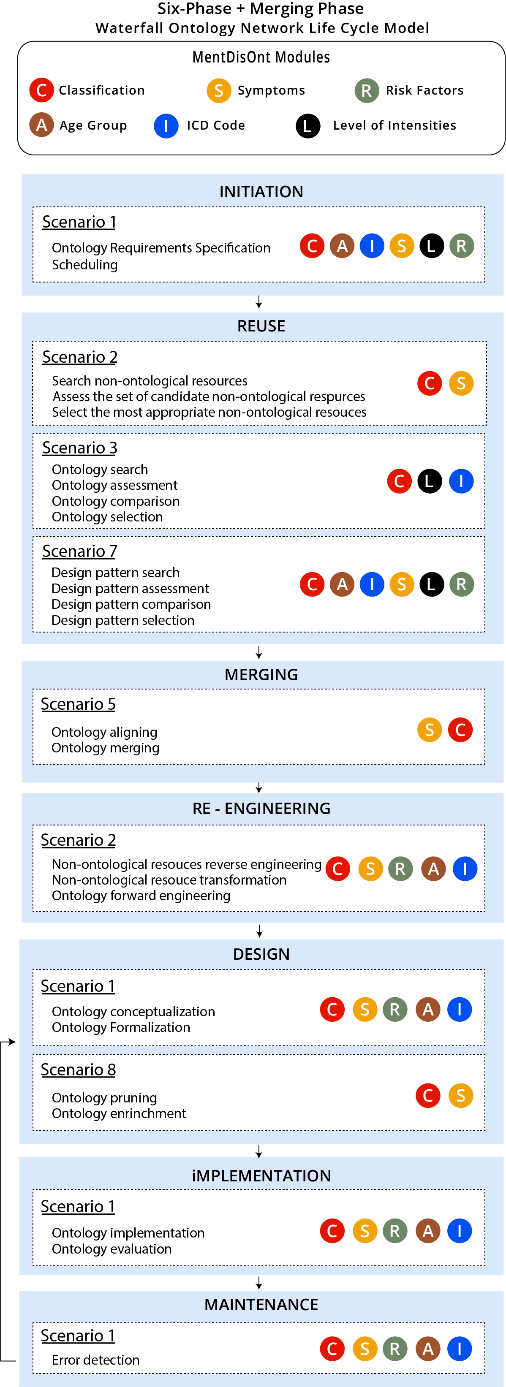
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Figure1

*4.1 Initiation:*

In collaboration with the Ms. Sadia Shadab, Psychologist and Mr. Fahad Maqbool, our supervisor, we created the Ontology Requirements Specification Document (ORSD) that contains among others, the purpose of the MentalDisOnt ontology, its scope and the Competency Questions (CQs), see Table 1. After a detailed analysis of those questions, it was noticed that they referred to five different dimensions regarding information related to Mental Disorders. Thus, the questions were classified in the following seven groups, one for each aspect, types, ICD codes, symptoms, comorbidity, risk factors, severity levels and age group. (Scenario 1).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Mental Disorder Ontology | | | | |
| SEEMP Reference Ontology Requirements Specification Document | | | | |
| **1** | **Purpose** | | | |
|  | The purpose of building the Mental Disorder Ontology is to provide a consensual knowledge model of the different types of mental disorders to be used by different users. | | | |
| **2** | **Scope** | | | |
|  | The ontology has to focus just on the different types of mental disorders, their types, symptoms, relevance, risk factors, and level of intensity. The level of granularity is directly related to the competency questions and terms identified. | | | |
| **3** | **Implementation Language** | | | |
|  | The ontology has to be implemented in OWL language. | | | |
| **4** | **Intended End-Users** | | | |
|  | . User 1. Mental health professionals.  User 2. People with Mental issues. | | | |
| **5** | **Intended Uses** | | | |
|  | Use 1. For gaining knowledge about mental disorders.  Use 2. To improve people's knowledge of different mental health problems/disorders.  Use 3. Gather information about different mental disorders.  Use 4. To help make the optimal diagnoses for a person.  Use 5. To describe different types of mental disorders. | | | |
| **6** | **Ontology Requirements** | | | |
|  | **a. Non-Functional Requirements** | | | |
|  | NFR1. The ontology must be consistent and should be able to answer all the competency questions.  NFR2. The ontology must satisfy the FAIR (Findable, Accessible, Interoperable, Reusable) principle. | | | |
|  | **b. Functional Requirements: Groups of Competency Questions** | | | |
|  | Group 1: Classification/Types  CQ1. Is a schizotypal personality disorder a type of schizophrenia spectrum disorder?  CQ2. How many types of Paraphilic Disorders are there?  Group 2: Code  CQ1. What is the ICD code of Fetishistic Disorder?  CQ2. What is the code of intellectual disability disorder if it has a profound level of intensity?  CQ3. Which mental disorder has the “F80.81” ICD code?  Group 3: Symptoms  CQ1. List the name of disorders that have breathing problems as their symptoms.  CQ2. What are the symptoms of Speech Sound Disorder?  CQ3. Is sleepwalking a sign of a mental disorder?  CQ4. Which disorder has trembling, palpitation, and chest pain as symptoms?  CQ5. How many symptoms a person must have to diagnose development coordination disorder?  Group 4: Correlation(comorbidity)  CQ1. Which disorders are correlated to schizophrenia disorder?  CQ2. Is cyclothymic disorder correlated to bulimia nervosa disorder?  CQ3. Could anxiety and depression occur together?  Group 5: Risk Factors  CQ1. What are the risk factors of posttraumatic stress disorder?  CQ2. Is Language disorder affected by genetic factors?  Group 6: Level of intensity /severity level  CQ1. What are the severity levels of intellectual disability disorder?  CQ2. How many symptoms a patient must have to diagnose a profound level of stress disorder  Group 7: Age Group  CQ1. Name the disorders that can only occur in children.  CQ2. Could neurocognitive disorder occur after the age of 50?  CQ3. Which are the minimum age criteria for the diagnosis of Alzheimer's disorder? | | | |
| 7 | **Pre-Glossary of Terms** | | | |
|  | **Terms from Competency Questions** | | | |
|  | Types  Disorder  Mental disorder  Symptoms  Genetic Factors  Severity Level  Diagnoses |  | Correlation  Comorbidity  Risk factors  Environmental factor  Temporal Factor  Level of intensity  Age group |  |

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