Ontology Based Case Retrieval in an e-Mental Health Intelligent Information System

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This chapter discusses on an ontology developed for a case based reasoning system that aims at the support of people facing autism spectrum disorders (ASD). PAVEFS is an intelligent information system designed for the personalized provision of services for the diagnosis and the care of individuals of various ages and types of autism. The objective of PAVEFS is to lead to best practices' models and to provide access to information regarding the care procedures of individuals with ASD. PAVEFS is based both on scientific knowledge of autism and on practical information, acquired from experts and caregivers from various specializations, aiming at the creation of an extended basis of specialized and reliable information and at answering questions related to care procedures of children and adults facing ASD.

Keywords: E- mental health, ontology, knowledge base, case-based reasoning system.

1. Introduction

E-Mental health, as a sub-domain of e-Health[1], may be defined as "the use of telecommunication and information technologies to deliver mental health services at a distance" [12]. Respectively, the National Health Service (NHS) Network, defines e-mental health as "the use of information and communication technologies to support and improve mental health, including the use of online resources, social media and smart-phone applications".

During the last decades, the rapidly increasing use of IT and specifically Artificial Intelligence techniques influences, among others, the delivery of mental health services, i.e. the provision of information, assessment, diagnosis, counseling and treatment. Broad definitions of e-mental health may also include delivery activities related to screening, mental health promotion and prevention, staff training, administrative support and research [16].

Mental health care is a major cost to all EU nations, as in many cases, results in additional costs to a country's economy. An ontology-enhanced monitoring and treatment model for assisting people to overcome the challenges of mental disorders is needed, since a well-designed ontology can serve as a good starting point as well as a more coordinated diagnosis and treatment. An ontology enables high scalability in searching, extracting, maintaining and generating information. Researchers have developed context ontology for mental disorders, especially psychological, psychiatric disorders or chronic diseases so as to serve as a basis upon which semantics and other methodologies and technologies can be developed for gathering, formalising and manipulating patients' data.

This chapter describes an ontology that has been developed for a Case Based Reasoning system aiming at the support of people facing Autism Spectrum Disorders (hereafter ASD). PAVEFS is an intelligent information system designed for the personalized provision of services for the diagnosis and care of individuals of various ages and types of autism. PAVEFS is a system based both on scientific knowledge of autism and on practical information, acquired from many experts and caregivers from various specializations, aiming at the creation of an extended basis of specialized and reliable information

[1]According to WHO definition e-Health is "the transfer of health resources and healthcare by electronic means".

and at answering questions related to care procedures of children and adults facing ASD. It is designed to operate as a bridge interconnecting standards, predictions and conclusions with data analysis and to provide effective and quality care procedures to individuals facing ASD. One of the main objectives of the PAVEFS system is to lead to best practices' models and to provide access to information regarding the care procedures of individuals with ASD. It is considered as a critical system based on a dynamic understanding of the nature a) of individuals facing ASD and b) of their care procedures.

The system's architecture is mainly based on users' (specialized/experts, analysts/ investigators, regular and advanced end users) access (information and answers' introduction) through PC, laptop, smart phones, tablets, VoiP, IVR, smart TVs, Fax, OCR. A specially designed form facilitates experts to introduce rules/exceptions and cases to the system's knowledge base, while users submit questions (queries), also through a specially designed form. Then, taking into consideration the profile of the individual facing ASD as well as the characteristics of her/his specific behaviors described in the question, the system searches in the knowledge base for similar cases. Finally, after processing the similar cases, the system returns both the similar cases and successful interventions per behavior.

The Ontology includes all the terms used for information regarding the profile, the rules, the exceptions, and the cases. The ontology is accessed each time a case/rule/exception/query is entered to system or each time a response is returned to the user. The knowledge base is consisted of cases, rules and exceptions represented by using terms of the Ontology. Also, the ontology terms are used to compose the end-users' questions, by giving to the users access to the Ontology. Finally, the response of the system consists of automatically composed text based on terms of the Ontology that includes information/consultations as well as similar cases represented by using terms of the Ontology.

The core of PAVEFS is a hybrid reasoner that is based both on case based and on rule based reasoning. It is based on experts' knowledge in order to gain an internal representation of characteristics of individuals facing ASD to compare with the characteristics of the individual to be examined. This knowledge is continually amplified with cases and rules that are derived from the knowledge and experience of specialized experts regarding autism as well as from the international academic literature.

PAVEFS includes also an expert system of primary diagnosis, as a screening tool, contributing to the on-time detection of ASD. The system provides a primary diagnosis tool using two alternative questionnaires, one for children aged up to 4 years and another one for children aged between 49 months and 11 years old. The user answers 23 questions presented in the first case and 15 questions on the second one. After the completion of the answering to the questions, the system provides an evaluation and diagnosis and decides whether there are some indications for ASD or not and always incites the user to visit a physician.

The remaining part of the chapter is organized as following: Section 2 describes the related work on the use of ontologies in e-mental health support systems. Section 3 describes the developed ontology, the knowledge base of the system and the hybrid reasoning model used by the PAVEFS system. Section 4 describes the evaluation methodology followed and the results. Section 5 discusses the conclusions and section 6 provides the plans for future work.

2. Literature Review

In related work, Young et al. incorporated an autism ontology to allow semantic data integration by annotating data with ontological concepts and enhancing queries on database. As Autism Spectrum Disorder is an inherently complex and somewhat vague phenomenon, there is difficulty in understanding its causes. The National Database for Autism Research

(NDAR) has been constructed to aid in providing a means for researchers to share and integrate data [17]. An autism ontology is being incorporated by NDAR to allow semantic data integration while its architecture enhances queries, central and federated, on databases, including the annotation of data with ontological concepts. The NDAR allows researchers to define the phenotype in terms of the elements in data dictionary, with the assessments and their items by also assigning accession numbers to phenotype and associating literature citations with them. The researcher could simply type a citation into NDAR to retrieve the phenotypes therein and alternatively, could get phenotype accession numbers from NDAR prior to publication, such that the phenotype accession number could be included in the publication itself. Additionally, the reader could simply search NDAR using the accession number to retrieve the phenotype and associated data.

Rodríguez-González et al. presented an ontology mostly targeted towards evaluation and diagnosis for Psychological Disorders [2]. Ontologies were created, to allow different sorts of formal reasoning and to support a new generation of DSS in mental health professionals. Mental diseases include remarkable data heterogeneity and two different clinical classification systems with no formal method of interconversion [10]. Recent and relevant works proposed mental disease ontologies to be consistent with other biomedical ontologies [6]. The ontology presented aimed to act as the cornerstone of PsyDis [5], a clinical diagnosis DSS, illustrating the main features of its design and implementation. A well-designed ontology can serve to interoperability challenges that many actual systems present as well as a more coordinated diagnosis and treatment among practitioners.

The same stands in the works by Lin et al. who presented an ontology-based method, utilizing a decision tree algorithm aiming to infer psychiatric disorders. Protégé software was used for the creation of the decision tree algorithm that constructed an ontology-based meridian method, serving as an example psychiatric disorder inference and as a knowledge – sharing platform. The method, by pinpointing an association between the meridian system and modern medicine may effectively detect a psychiatric disorder and may also build expert knowledge by constructing domain and task ontologies [4]. The aim of the system is to eliminate the information disparity between patients and physicians while allowing experts to participate and to provide an understanding to the public. The study in general integrates an ontology-based approach with a decision-tree algorithm for the detection of psychiatric disorders.

Silva et al. also developed an ontology with the same objective, to infer psychiatric disorders upon symptoms. As the human brain is a very complex organ, it makes the diagnosis of this kind of illnesses a hard task. However, the diagnosis and treatment of mental disorders is the attempt to secure mental health in the human beings. Considering this, an ontology was conceived with the task of inferring one or more psychiatric disorders depending on the symptoms presented by a patient [14].

Hu et al. use also context ontology to regulate and accumulate patient data and an ontology-based inference engine to achieve personalization. Because of the high cost of mental health care to all EU nations, cognitive behavior therapy (hereafter CBT) is the treatment of choice for mental disorders such as depression, anxiety disorders, eating disorders, chronic insomnia, etc. The study proposes a context ontology for mental disorders as the basis on which semantics-enhanced methods are developed for gathering, formalizing and manipulating patients' data [8]. The diagnosis and treatment of mental disorders is multidisciplinary including sciences like medicine, sociology, psychology and computer science. The system integrates an online statistic report while the proposed framework provides access to CBT programmes available through PDAs, smart phones and other handheld devices.

Vyas et al. presented an ontology based decision support system that mostly helps handling and tracking patients' records, facilitating quick accessed and specialized health care services, depending on the patient's or case history. Consequently, the time spent to medical institutions is reduced. The system provides a fast and up to date patient health data thus reducing the documentation and formalities and increasing the usability of the effective and reliable information by the medical institutions and health care specialists. The available data within the healthcare system usually lack effective analysis tools to discover hidden relationships and trends into them. Ontologies enable high scalability in searching, extracting, maintaining and generating information [15]. Additionally, with the use of e-health care systems, patients receive better, faster and more coordinated health care and on the other hand providers share information more effectively.

Diego et al. use ontologies to annotate stored data about Mental Health with metadata, to try to improve interoperability between Information Systems. Mental health managers need to take decisions with complex data from dispersed sources with low levels of standardization and integration. The interoperability between Information Systems is an essential characteristic to establish the capacity of communication, exchange and reuse of information for the generation of knowledge. Semantic Web technology can be used to reduce the data complexity and to assist in the data interpretation since it classifies the stored information with metadata and gives them meaning through the ontologies [7]. The proposed ontology intends to integrate databases of different natures in the RAPS, allowing the semantic marking in the raw data and transforming them into information, knowledge, and intelligence in a later stage. The ontology provides improvements to the RAPS decision-making and to the creation of public health policies by providing the manager with information from various working independently systems.

Ajami et al. have developed a decision support system to help Chronic Obstructive Pulmonary Disease (hereafter COPD) patients, using a relevant ontology and SWRL rules. The study investigated formal semantic standards used for building an ontology knowledge repository to provide ubiquitous healthcare and medical recommendations for COPD patients to reduce preventable harm. The proposed approach is patient-centered monitoring and its main benefits are: the adhering of safe boundaries for the vital, signs[2], the assessment of environmental risk factors; and the evaluation of the patient's daily activities through scheduled events to avoid potentially dangerous situations [1]. The solution implements an interrelated set of ontologies with a logical base of Semantic Web Rule Language (SWRL) rules derived from the medical guideline's research and independent expert (pneumologists) opinions to estimate the risk of COPD exacerbation and handle all contextual situations. A decision support system was developed to create safe environments for COPD patients in ontological formal description of a health-related domain using SWRL rules. The proposed ontology contains all relevant concepts related to chronic obstructive pulmonary disease, including personal information of patients, localization, activity, symptoms, risk factors, laboratory examination results and treatment plan.

The future steps for the researchers are the testing of the above described systems with many practical data and in a variety of application scenarios (i.e., outdoor and indoor). Follow-up studies need to produce systems in a real-life medical practice to increase the available detections for different mental disorders. By capturing sufficient data regarding different disorders, systems will be able to detect disorders and uncover the valuable relationships between them, bringing added value to medical practice.

[2] varying on many factors;

Next challenge to meet is the application of the systems on other types of mental disorders, and the expansion of context ontology with the inference engine into a more general mental disorder health care ontology. OWL with SWRL can be used for handling reasoning in complex medical systems while another issue remains the automatic construction of ontologies from the clinical database so that the learning process of the e-health care system to be continued with the passage of time. The use of ontology improves the quality of service and contributes to a better allocation of resources bringing benefits to every society by increasing performance and effectiveness in the public health sector. Furthermore, the use of such systems, can improve a) patients' ability to engage in self-management and b) the expansion of applying the approach to other mental or chronic diseases.

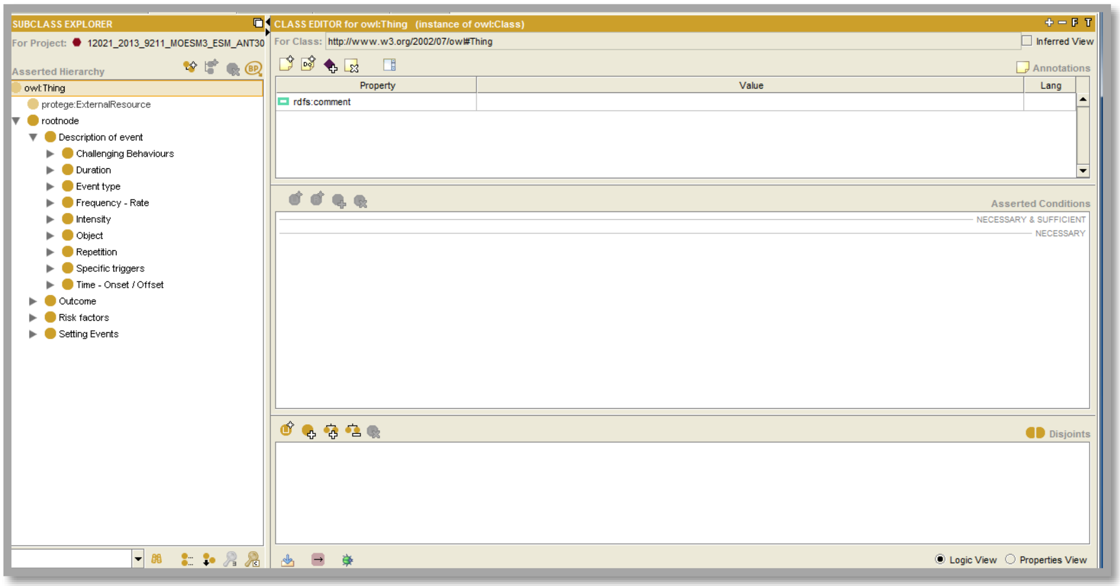
3. The PAVEFS Ontology

The Ontology is served as a logical model providing the opportunity to represent knowledge of specific domains, describing the contexts of the domain and the relations between them. For the creation of the PAVEFS' ontology, Protégé [13] has been used for facilitating the visualization, the data retrieval, the usage of inference mechanism etc. The ontology represents in tree format the concepts used in cases and rules' induction. It includes the existing ontology from Harvard [7, 8] while, with experts' intervention, it has been extended to cover all the implementation needs. More complex concepts are described with more simple concepts' definitions. Furthermore, control for the mutual validation of statements and definitions is conducted while the depiction of the combination of the concept with the relevant definition and the proper hierarchy contribute to domain understanding. New terms have been added or renamed and the ontology has been restructured with the aim to describe the cases in a more understandable way for the user/people, not expert in autism domain.

The ontology's structure is created so as to facilitate the user, the expert or any other to describe an incident. The ABC (Antecedent – Behavior – Consequence) approach is followed so as to respond to system needs. From the structure it is obvious that at first a risk factors reference is made (contribution to the appearance of the behavior, taking account the medical record and patient's diagnosis), then the incident (description of event) with the behavior and the parameters (such as frequency, tension etc) is described. More parameters added according to the environment (natural and people) before and during the event (setting events) and finally the actions for the confrontment of the incident, possible dangers and the results of the comportments (outcome) are presented.

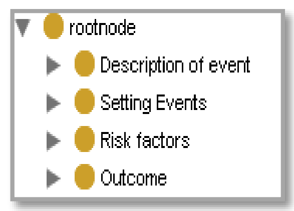
The Ontology is a hierarchical tree of classes (concepts relevant to autism) with the objective to cover all the necessary vocabulary for the case representation (a specific event and the way it is confronted) and the rules (conditions and conclusions). The OWL file consists of the statements of classes, hyperclasses and their labels (rdfs: label). The schematic illustration of classes in Protégé environment is presented in Picture 1.

Picture1: Classes in Protégé Environment



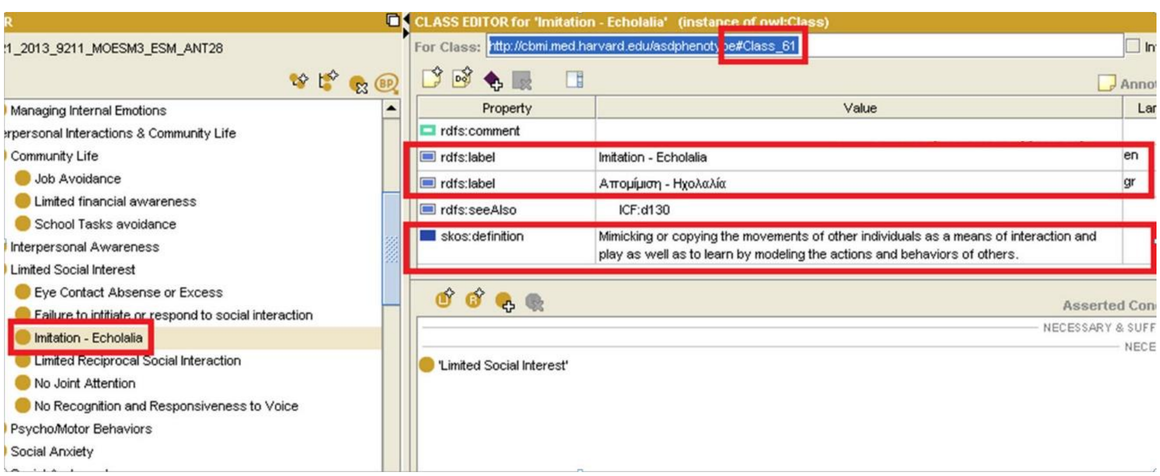
Each class may consist of other classes and subclasses (Picture 2 and 3) each one with a unique ID. For the definition of the label we use “label” (many languages) and for the definition of a concept description the feature “definition” is used. The schematic illustration of classes and labels is presented in Picture 4.

Picture 2: Classes/Hyper Classes



Picture 3: Classes and Subclasses in Protégé Environment

Picture 4: Labels and Classes definitions



The proposed ontology includes six (6) basic classes (Age, Antecedents, Binaries, Description of Event, Outcome and Profile Information). The "Age" includes seven (7) nodes, describing the new-born, infant, school, teenage, young-adult, adult and mature age depending on the years the individuals have at the time of the event. The second class "Antecedents" includes six (6) other classes (‘Location’, ‘Number of people involved’, ‘Physical environment’, ‘Specific triggers’, ‘State of the person’ and ‘Who was involved’) that all except from the second (Number of people involved) also include subclasses and nodes. “Location” contains three more classes (Indoors, Outdoors and Vehicle) and three more nodes (Other Therapeutic/training, environment/clinic, School/College, Work/Vocational Experience). The number of people involved is used to determine if the incident happens when the individual is alone, with someone else or with more people. The class of physical environment is consisted of five more classes (Change, Lighting, Noise, Temperature and Weather) and four more nodes (Busy or Crowded environment, Environment with lots of stimuli, New environment, No structure of physical environment). The “Specific Triggers” class extends to thirteen more classes (Demand, Diversion, Event, Lack of power/control, Lack of simulation/motivation, Lighting, Location, Noise, Sensory stimuli, Temperature, Weather, Known person, Transition), and three nodes (Busy or crowded environment, Not apparent at time of incident, Unknown person (involved)). The classes mentioned are also extended to two of three more levels of nodes. The “State of the person” class contains four more classes (Emotional State, Health State, Mental Health State and Physical Health State). The emotional and physical health state classes are extended to one more level (containing two more classes containing subclasses). The “Who was involved” class contains one class (Known person) – with one subclass (caregiver) with two nodes (Female, Male)- and a node (Unknown person).

The third class “Binaries” includes ten (10) other sub-classes (requiring a value YES or NO). The fourth class “Description of event” contains five (5) more sub-classes (body part involved-28 nodes, frequency rate-high/medium/low, incident type with eleven (11) more subclasses, intensity -high/medium/low/variable, location during the event). The location during the event contains three (3) classes-indoors/outdoors/vehicle and three (3) nodes-other therapeutic/training environment/clinic/work/vocational experience. The fifth class “Outcome” consists of four (4) more classes (Person, Response, Restrictions, and Risks). The “Person” sub class includes four (4) nodes while “Response” class contains nine (9) sub classes and eighteen (18) nodes, referring to all the possible responses in the ASD. The “Restrictions” class includes the Environmental sub class (with four nodes) and the Liberty node. The “Risks” class includes two other classes “To Others” with five nodes and the “To Self” class containing six more nodes. Finally the sixth class, that is the biggest class of the ontology, “Profile Information” consists of three other classes (Diagnosis, Gender, Risk History/Factors). The Diagnosis class includes eleven (11) subclasses expanding from 5 to 41 nodes and five (5) nodes. The Gender consists of three nodes while the Risk History/Factors contains five (5) classes and one node. The five classes expand to other classes and nodes (from two to four levels).

As an example the graph of the class “Event” is presented in Picture 5.

Picture5: Graph of the sub tree of the class «EVENT»

The field ID is the unique key of each record while the field NodelD refers to the unique number of each ontology node. The field OntologylD refers to the unique key of the ontology file to which the specific node is included. The fields LabelEN, LabelGR and DescrEN, DescrGR refer to the name and description of the node in the two languages the system supports. In ParentNode and SiblingNodes the node-father and node-children of each node are stored while the field FieldPrefix refers to the category the node belongs to (special trigger, behavior, etc). All the above mentioned fields are concluded in the OntologyNodes Table of the system.

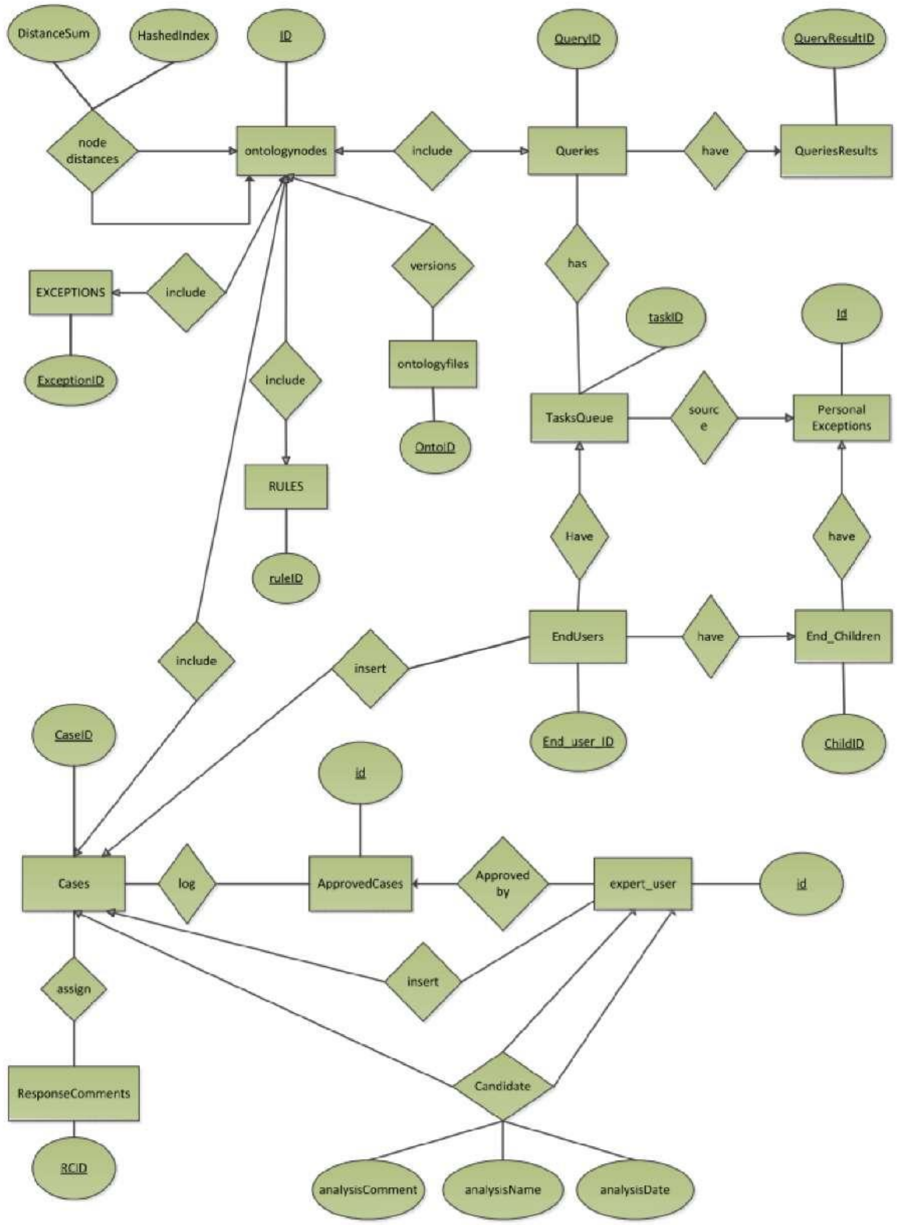
3.1. Knowledge Base

PAVEFS is based on a Knowledge Base consisted of cases, rules and exceptions to rules. The knowledge base is constantly updated with cases and rules, derived from the knowledge and experience of the autism experts but also from international academic literature, as well as from cases submitted by end-users, after evaluation by experts.

More specifically, the PAVEFS' knowledge base includes rules, originated by the experts' team and by other scientific studies on the confrontment of autistic behaviors. Rules describe general behavior standards, reaction ways to specific stimuli and conditions, crisis cases and the procedures needed until the restoration to the previous normal condition. The knowledge base is oriented to provide information and knowledge to users and it can update the data through review and evaluation functions.

It also includes a great number of cases that have been introduced to the system by experts. As the knowledge base is growing the system is becoming more efficient and accurate. The knowledge base includes general rules applying to general cases of individuals facing ASD, more specific rules (exceptions) deriving from the review of general rules that also apply to all individuals with autism and personal exceptions regarding specific cases of ASD individuals, exceptions deriving from the review of general rules applying only to specific individuals. A case record includes all the relevant information regarding an autism related incident. The fields of a case can be grouped in the following group categories: Individual's Profile and History, Environment and involved People, Antecedents, Behaviours, Response Actions, Risks. The case also includes temporal data of up to three sequential periods, so it is possible to represent how the behaviors changed after specific response actions. The majority of the fields take as values Entities from specific branches of the Ontology.
A schematic illustration of the database implementing the knowledge base of the system is presented in Picture 6.

Picture 6: Schematic Illustration of PAVEFS Database



3.2. Reasoning

PAVEFS has a hybrid reasoning system which is based both on case based and rule based reasoning. Rule based reasoning (RBR) uses a set of rules (rule base) that represents general knowledge about a domain. A rule usually has an 'if-then' format, with a number of conditions that need to be satisfied for the rule to be activated and a set of actions or conclusions that are added in the working memory when the rule is executed. Inference takes place by introducing the input to the rule base, causing a chain of rules to be triggered and executed that eventually lead to the output. Rule based reasoning is appropriate when there is a clear model of the domain or there are available experts that can represent it in the form of rules. Case-based reasoning (CBR) takes advantage of stored past cases in order to deal with new similar cases. The inference is usually performed in four phases knows as the CBR cycle: retrieve, reuse, revise, retain. Retrieval regards finding in the set of stored cases one or more cases that appear to be the most similar to the new case. Reuse is concerned with using the retrieved, relevant cases to propose a solution for the new case. Revision regards the validation of the proposed solution, by testing if it solved the problem at hand. Retain decides if the new case is useful enough to be stored in the pool of past cases. Case based reasoning is appropriate when there is great number of past cases available or it is easy to obtain them. It does not rely on creating a model of the domain.

RBR and CBR have been widely used together in systems in various applications and domains with quite successful results. One of the reasons for this is that they seem to have complimentary capabilities, so a system that can utilize both approaches could potentially take advantage of the positive aspects of both while minimizing the negative aspects. Furthermore, this combination of general (rules) and specific (cases) knowledge emulates the human way of thinking. Hybrid reasoning models that utilize both RBR and CBR components have been used in various domains with most notable the Legal, Medical and Agricultural. The way that the components are used in a hybrid system varies greatly and there have been a few attempts to categorize them. Medsker [11] has proposed a general categorization for combining intelligent techniques taking account whether and how the different integrated components interact with each other, which was later extended by Prentzas & Hatzilygeroudis [9] to better represent hybridizations with CBR components.

In the PAVEFS reasoning scheme, a cased based reasoner is the main component of the architecture, with the most crucial role. Also, a rule based reasoner utilizes rules provided by the experts to enhance the knowledge in the case base by populating it with additional values. Rules also include specific exceptions, provided both by the experts and extracted from the history of stored cases.

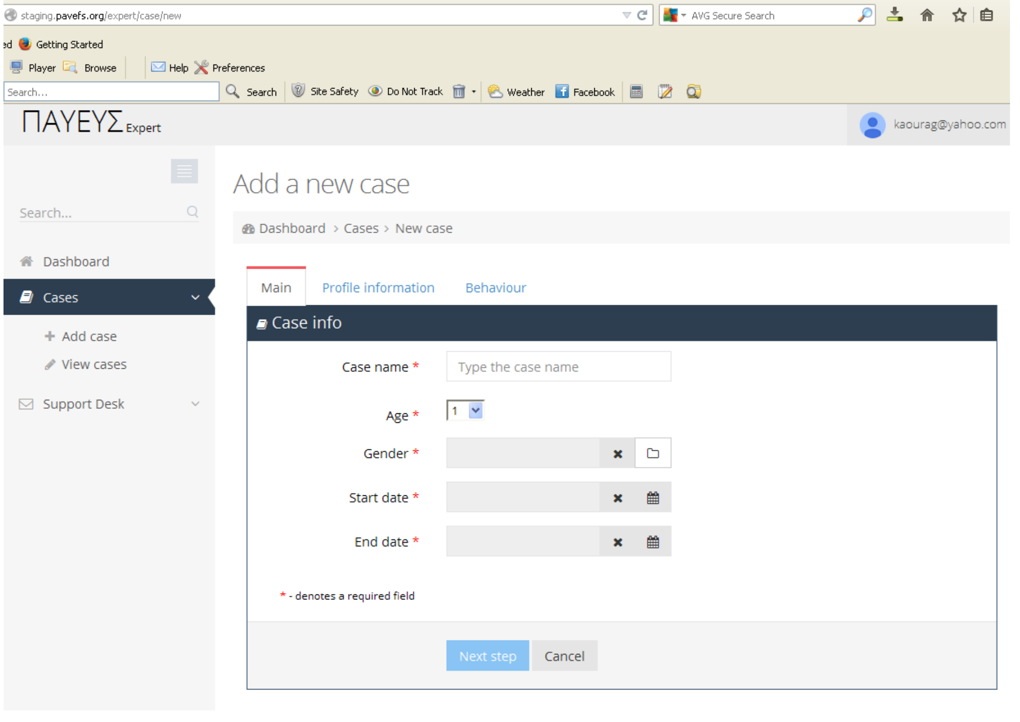
The reasoning system of PAVEFS, (along with its user interface) is based on an ontology including all the terms used for information regarding patient profiles, rules, cases and exceptions. The ontology is accessed each time a query is inserted by the user and a case/rule/exception is fetched, as a respond to this query. Thus, the key idea behind the reasoning system of PAVEFS is, given a new case of problematic behavior(s), to identify both the related rules and the most similar cases, in order to automatically adapt the corrective responses that were used in these cases and to suggest suitable actions.

Given the large amount of different features that represent a case and the fact that each case may contain multiple parallel and sequential sets of behaviors, the comparison between two different cases, to calculate a representative overall similarity measure, was one of the most challenging and complicated parts of the system and a part that required a lot of fine tuning to achieve optimal results. For each individual feature of the case, a calculation method has been determined according to the range of values. If the values of a feature are populated from a specific sub graph of the ontology, we use a specialized method that calculates the distance of the nodes inside the graph [3]. Regarding the temporal data representing subsequent transitions of behaviors of an individual, we try to identify patterns of behaviors that happen concurrently or subsequently. A case may represent multiple behaviors, antecedents and other features happening concurrently, so for each one of these features we compare two cases using suitable similarity measures for sets of items such as the Homer metric that depends on the number of shared items between the two sets. We actually applied and tested many different similarity measures for the comparison of sets to come up with the most suitable metric for each feature. Finally there are specific weight values that have been associated with individual features or groups of features according to their significance towards the calculation of the overall similarity score. Thus the final similarity value between two cases is calculated as a weighted average of the similarities in the individual features. Coming up with the suitable values for the weights (significance) of each individual feature in a case, was a painstaking process that combined both the opinion of experts and trial and error methods.

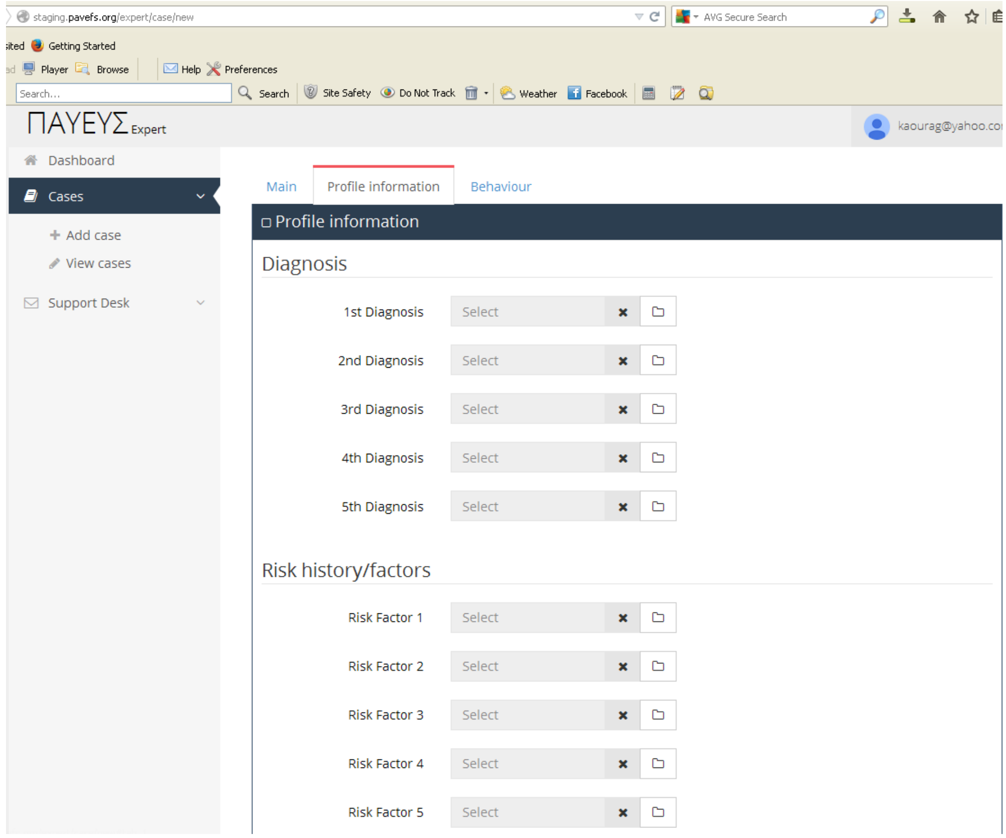
3.3. User Interaction

The user interacting with the PAVEFS system, may add an individual for whom he adds continuously information such as a code, the birth month/year, the gender, the diagnosis date, the functionality level, the education category, the insurance type, the diagnosis (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}) and the risk factors (1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th}). As soon as the individual has been added the user may add a new query for him/her by providing a name for the identification of the case. In the section that follows the user can add some general information regarding indications and/or medical history of the person who caused the event based on a menu of available options, such as formal diagnoses and other risk factors that may have an impact on the etiology or course of challenging behaviors. At the next stage, the user describes the specific event that took place by starting with the first behavior (Behavior 1 - period 1) that occurred. The description includes the selection of the specific fields representing the information of ontology's classes/sub-classes and nodes and after completing all the forms related to the first behavior (antecedent, behavior, outcome) he continues with completing another form, given that there was another behavior happening simultaneously or close in time (see the following screenshots of the system).

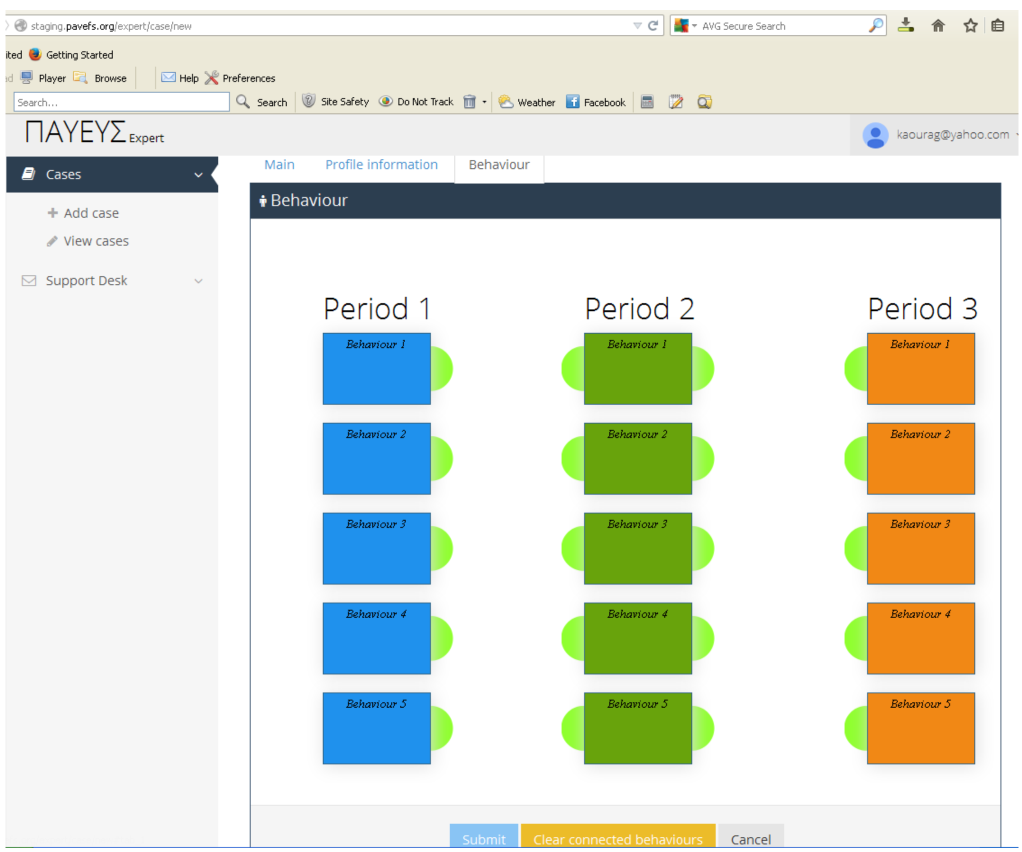
Picture 7: Adding a new case



Picture 8: Adding diagnosis per case.



Picture 9: Describing a behavior during 3 periods



4. Evaluation Methodology and Results

Depending on the characteristics of the individual facing ASD, system includes the critical examination, evaluation and implementation of the knowledge base and the ontology of PAVEFS but also the testing of new practices for the confrontment of ASD.

4.1. Evaluation Methodology

According to Rumble (1997), effectiveness concerns the outputs of the system, organism, software etc with regard to the "customers" or "final receivers" needs. Based on this approach, for evaluating the effectiveness of the software, the objectives to be achieved and the weight of each objective/evaluation criteria need to be documented. Depending on the software, the involving parts and the person conducting the evaluation, there are used different criteria and different weights for each one of them. The development of an evaluation plan for the system has been realized in line with the objectives of the program. The main evaluation field with regard to the Technology Usage concern:

- **Friendly usage**: The parameter corresponds to the environment of the program for a common user as well as for a more expert user.
- **Efficiency:** The parameter refers to system effectiveness, developed under the sight of answering all the questions submitted by users and their satisfaction from the system's answers. It refers to the quality of the information given by the system and also to the possibility of confrontment of an incident by distance (without the involvement of the professionals).
- **Availability:** The availability refers to the access to PAVEFS and constitutes a closed application since the access is not open and the user needs to make a registration for entering the system.
- **Usability:** Usability has to do with various characteristics contributing to the easier access to the application**.**
- **Reliability:** The parameter ensures that the system developed, after its use and test and trial method of real users promotes interaction and feedback, it is objective oriented, permits the experimenting on real situations, the users can understand how to navigate and to which point of the software are at any time (there are some procedure control tools available for the user **-** queries history, individuals list etc.) and the personal usage of the software is ensured.
- **Completeness:** Completeness refers to the degree the application covered the needs of the families that have individuals with ASD, to the effectiveness of the proposed solutions and to the degree the application is used on a daily basis.
- **Clarity:** Clarity is expressed in the application with the explanation of the terms and concepts, with the explanation of ontology concepts or with the definitions appearance either with text, image or hyperlink or video for the candidate values as for the results of the application use.
- **Material Quality:** The parameter concerns the list of nodes that is called «Ontology». The ontology concerns the general terms and the more specific terms as subcategories of the general ones. Additionally, it includes the incidents stored to the knowledge base from the specialists/professionals that amplifies the knowledge base and provides more accurate and complete information to the users.
- **Software quality:** Users consider the software of «high quality» if it corresponds to what they want with an easiness for the use and learning way, by using the resources or by using a portable device right and efficiently and when the experts may design, codify, control and maintain the system easily.

4.1.1. Evaluation Tools

Alpha-TESTING

The collaborating experts were asked to control the proposed interventions as system responses (A-testing). The control completed with 358 queries, submitted by the experts based on real incidents with children and individuals facing ASD that differentiated upon user type. The evaluation of the queries took place in four phases:

1st phase: Trial users: At the first phase of the trial queries insertion, 22 experts had to login to the application and insert 50 queries, each one based on real circumstances. Then the experts evaluated the system's results, the proposed interventions and the proposed real incidents provided.

2nd phase: Regular Users: At the second phase of the trial queries insertion, experts though a special process have become regular users and inserted 25 queries each, based on real circumstances. The users – experts as regular users had initially to register a number of persons with diagnostic and other characteristics so that they can use them to the insertion of the query followed. The fields of the ontology used were more than those of the trial user and after the insertion of the queries the users evaluated the results of the system, the proposed interventions and the proposed real incidents.

3rd phase: Advanced Users: At the third phase of the trial queries insertion, experts have become though a special process advanced user and inserted 25 queries each. As advanced users, they had the same rights with the regular users (to insert and evaluate queries) and an extra opportunity to evaluate the proposed interventions in a special application tab. After they evaluated the interventions as absolutely successful/partial successful/absolutely unsuccessful, the system stored this evaluation and created personal exceptions for each user. At a next stage when they were asked to register the same query and evaluate the proposed solution, they were asked also a) to certify that the new interventions proposed didn't include the already negatively evaluated (on a former stage) solutions and b) to evaluate the new interventions. After the insertion of the queries the experts evaluated the results of the system for two times.

4th phase: Queries per period: At the fourth phase of the trial queries insertion, experts as advanced users had to insert almost ten (10) queries as followed:

- to choose queries from the third phase for which at fist the intervention proposed were negatively evaluated by users.
- to register again a new query which at the first period had the same information with the one already inserted on third phase and to register all the interventions (positively and negatively evaluated) of the system at the first stage of third phase.
- to answer positively to the question if there were next period to the comportment and to insert a new period (2nd period) with the possible comportment, without answering to the question if the system corresponded to the comportment of the second period so as to receive an answer of the system and to evaluate the corresponding answer (proposed interventions and incidents).

A similar procedure was followed for the third period of the query registration and the forms with the experts' answers have been stored.

4.1.2. Results

The processing of the results of the 1st and 2nd phases demonstrate that 61% of the proposed interventions have been absolutely accepted, 21% were partially accepted, 10% were stated as «problematic» while 8% of the queries hadn't been answered by the system and no intervention was suggested because there were no relevant knowledge in the knowledge base.

Starting the evaluation, the ontology's comportments for which there were no rules or incidents in the knowledge base were searched. Then the base was amplified by the experts with the relevant rules and incidents and the system responded even to those cases with low acceptance by the experts' interventions. Then the incidents to which the system responded problematically (10% of the cases) were searched. The incidents were corrected and the expertise from the correction (mainly ontology changes) was implemented to all the incidents of the knowledge base. So, the system responded problematically only to 4% of the overall cases. The reliability of the system has been also evaluated, 72% stated they absolutely accept the proposed interventions, 24% stated they partially accept the proposed interventions and 4% considered as «problematic» the proposed interventions.

For the third phase and the answers of the experts it is concluded: Experts evaluated positively the results of the queries submitted by the advanced users by 80%. They agreed with the majority of the interventions and even in cases of disagreements the reason was only the order of interventions' appearance. So, the percentage could approach 90-95% respectively if not taking into account the order of the proposed interventions' appearance. Regarding the queries that the users evaluated as «unsatisfying» only one out of four intervention did not fit. The one intervention evaluated as unsuccessful in the system created a personal exception for the individual so as not to be proposed again. This was also checked by the experts in a next stage. For these cases they were led to the second procedure of the insertion of the same query repetitively, after the negative evaluation of the interventions. Then the system operated successfully and created the personal exceptions. It proposed alternative interventions that were evaluated by the experts in average as more adequate.

During the 4th phase and the answers processing: The experts followed the already described procedure to insert queries in periods, as in the previous stage. More precisely they chose the queries for which the system did not propose the most successful interventions at the stage of the advanced user and they inserted again, by proceeding with the proposed interventions in second period. They were asked to insert ten (10) such queries, but experts didn't reach the number because there were no such incidents in the third phase, so they inserted new queries in order to find some for which the proposed interventions were not effective. This was a time consuming process and the system had already reached the level of almost 95% acceptance. According to the evaluation, over 80% (almost 84%) of the proposed interventions were satisfying and could be effective in their use. For the cases evaluated as unsuccessful, it has to be mentioned that at the majority only one didn't fit. The comments of the negatively evaluated queries usually concerned a series of proposed interventions or at least one that could be replaced by another one more adequate and commented as of absolute rejection of the intervention.

Beta-TESTING

The phase "Beta-testing" started just before the conduct of conferences for the presentation of the system. The methodology predicted that after the theoretical presentation of PAVEFS the attendants of the conferences could try the system on real time so as to test its efficiency. The attendants by giving some information to the system submitted a query. In real time the user could evaluate the usability and the results.

It is worth mentioning that most of the attendants stated being "impressed" with the ontology terms accuracy and especially with the total number and the variety of the terms since they included most elements of the daily life of a child facing ASD. The attendants were asked also to use the application from the environment of their home, since users registered to the system and started their queries. The most interesting part was that during the demonstration conferences some relevant with ASD societies were excited with the implementation of the system.

5. Conclusions

The application of information systems in health has achieved to overcome very important obstacles and to offer better solutions with more accurate and reliable use of medical data. E-health covers different tools and applications based on information technology and communication, targeting to improve prevention, diagnosis, treatment and to provide better health management leading to a better quality of life. In this perspective, the system proposed introduces a new approach for the confrontment of ASD. The fact that a user may enter the system from wherever he/she desires (either from home during his free time and for free or from any other place) is added value to the application, helping practically to the health management problem.

The possibility of on time and in-time process of many information regarding comportment, antecedents, the individual's environment etc, provides the background for the right decision making by an individual for another one. The ontology contributes to the more accurate descriptive depiction of the clinical image of individuals facing ASD and to the presentation of the proposed interventions.

Additionally, through the Primary Diagnosis tool that has been developed, the possible finding of indications of ASD is innovative since it could awaken not only parents and relatives but also specialists and teachers, that may identify the indications through the questions applied. So, it has a consultative role for the individuals involved and can be a useful tool on the hands of the specialists, contributing to the effectiveness of their work, since it is based on key-user's method by using their professional experience and providing it to the user.

6. Future Scope

The ambition of the researching team is to expand the ontology/system or the approach in general to other mental or chronic diseases in order to achieve a better handling reasoning in complex medical systems and to contribute to a better service quality and to increase the performance and effectiveness in the public health sector. One of the next challenges should also be the work on the testing of the proposed implementation to the conclusion of other sectors needing systematic analysis of complex data and interventions for the decision making.

REFERENCES

1. Ajami, Hicham&Mcheick, Hamid. (2018). Ontology-Based Model to Support Ubiquitous Healthcare Systems for COPD Patients. Electronics. 7. 371. 10.3390/electronics7120371
2. Alejandro Rodríguez González, Jose MaríaÁlvarez Rodríguez, Cristina Casado-Lumbreras, and Ricardo Colomo-Palacios. 2012. Towards an ontology for psychological disorders. Int. J. Metadata Semant. Ontologies 7, 4 (January 2012), 260-268.
3. B. Boutsinas and T. Papastergiou: On clustering tree structured data with categorical nature, Pattern Recognition, 41, pp. 3613-3623, 2008.
4. C. Lin, Y. (2010). Design and Implementation of an Ontology-Based Psychiatric Disorder Detection System. WSEAS Transactions on Information Science and Applications. 7. 56-69.
5. Casado-Lumbreras, Rodríguez-González, A., Álvarez-Rodríguez, J.M., & Colomo-Palacios, R., (2012). PsyDis: Towards a diagnosis support system for psychological disorders. Expert Systems with Applications, 39(13), 11391–11403.

6. Ceusters, W., & Smith, B. (2010). Foundations for a realist ontology of mental disease. Journal of Biomedical Semantics, 2010(1), 10.
7. Diego Bettiol Yamada, Vinicius Tohoru Yoshiura, Newton Shydeo Brandão Miyoshi, Inácia Bezerra de Lima, Gustavo Yukiu Usumoto Shinoda, Rui Pedro Charters Lopes Rijo, JoãoMazzoncini de Azevedo Marques, Maria Manuela Cruz-Cunha, DomingosAlves. Proposal of an ontology for Mental Health Management in Brazil. Procedia Computer Science. Volume 138. 2018. Pages 137-142. ISSN 1877-0509.
8. Hu, B., Wan, J. , Dennis, M. , Chen, H. , Li, L. and Zhou, Q. (2010), Ontology‐based ubiquitous monitoring and treatment against depression. Wirel. Commun. Mob. Comput., 10: 1303-1319.
9. Jim Prentzas, Ioannis Hatzilygeroudis: Categorizing approaches combining rule-based and case-based reasoning. Expert Systems 24(2): 97-122 (2007).
10. Kola, J., Harris, J., Lawrie, S., Rector, A., Goble, C., & Martone, M. (2010). Towards an ontology for psychosis. Cognitive Systems Research, 11(1), 42-52.
11. L.R. Medsker, Hybrid Intelligent Systems, Kluwer Academic Publishers, Second Printing, 1998.
12. Mucic D, Hilty DM (eds) (2016) e-Mental health. Springer International, Cham.
13. Musen, M.A. The Protégé project: A look back and a look forward. AI Matters. Association of Computing Machinery Specific Interest Group in Artificial Intelligence, 1(4), June 2015. DOI: 10.1145/2557001.25757003.
14. Silva C., Marreiros G., Silva N. (2014) Development of an Ontology for Supporting Diagnosis in Psychiatry. In: Omatu S., Bersini H., Corchado J., Rodríguez S., Pawlewski P., Bucciarelli E. (eds) Distributed Computing and Artificial Intelligence, 11th International Conference. Advances in Intelligent Systems and Computing, vol 290. Springer, Cham.
15. Vyas, Nitesh & Pal, Parashu. (2012). E-Healthcare Decision Support System based on Ontology Learning: A Conceptual Model. International Journal of Computer Applications. 59. 12-16. 10.5120/9575-4050.
16. Wolfgang Gaebel, Isabell Groίimlinghaus, Ariane Kerst1, Yoram Cohen, Andrea Hinsche-Bockenholt, Bert Johnson, Davor Mucic, IonelaPetrea, WulfRφssler, Graham Thornicroft, JórgenZielasek, " European Psychiatric Association (EPA) guidance on the quality of eMental health interventions in the treatment of psychotic disorders". European Archives of Psychiatry and Clinical Neuroscience, March 2016, Volume 266, Issue 2, pp 125–137.
17. Young, Lynn &Tu, Samson &Tennakoon, Lakshika &Vismer, David &Astakhov, Vadim& Gupta, marnath & Grethe, Jeffrey &Martone, Maryann & Das, Amar & Mcauliffe, Matthew. (2009). Ontology driven data integration for autism research. 2009 22nd IEEE International Symposium on Computer-Based Medical Systems. 1-7. 10.1109/CBMS.2009.5255362.