International Journal of Data Mining Techniques and Applications
Volume: 04 Issue: 02 December 2015 Page No.59-62
ISSN: 2278-2419

A Bayesian Framework for Diagnosing Depression Level of Adolescents

M.R.Sumathi[1], B.Poorna[2],
[1]Research Scholar,Asst. Prof. and Head,Department of Computer Applications,
Sri KanyakaParameswari Arts & Science College for Women, Chennai, India
[2]ResearchSupervisor,Principal,ShriShankarlalSundarbaiShasun Jain College for Women,Chennai, India
Email: sumathikuben@yahoo.co.in, poornasundar@yahoo.com

Abstract - Depressive disorder is an illness that involves the body, mood and thoughts. It interferes with daily life, normal functioning and causes pain for both the person with the disorder and those who care about him/her. Severe depression may lead to serious illness or suicide. The most affected sector is the Adolescent Community. The biggest problem in diagnosing and treating depressive disorders is recognizing that someone is suffering from it. As various factors are involved, it is very difficult for the Psychologists to diagnose depressive disorders correctly at an early stage itself. Nowadays, computers are used in assisting Physicians to diagnose diseases and identify correct treatments according to the patient details. In the same way, computers can also be used in assisting psychologists to diagnose mental disorders and identify correct treatments according to the patient details. Various techniques are available to store the expert knowledge and computerize the diagnosis process. Bayesian Network is such a technique that combines statistics and expert knowledge to diagnose diseases effectively. This paper proposes a Framework for diagnosing depression level in adolescents using Bayesian Networks. Initially, Ontology should be constructed to provide a basis for Bayesian Networks. The ontology acts as the topology and shows the relationships between adolescent depression concepts. By applying probabilities to the relationships between concepts from the statistics, and by using Bayes Theorem, depression level of a patient can be diagnosed effectively. This framework may help novice psychologists to understand the domain concepts and also to diagnose the depression level and suggest correct treatments.

Keywords—Ontology, Bayesian Networks, Depression, Diagnosis

I. INTRODUCTION

The term*depression* was derived from the Latin Verb "de primere" meaning "to press down" [21].The history on diagnosis of depression starts from the period of *Hippocrates, the ancient Greek Physician.* He characterized all "fears and despondencies, if they last a long time" as being Symptomatic of the ailment that was similar but far broader concept than today's depression.According to Indian Journal of Psychiatry, Depression is a disorder of major public health importance, in terms of its prevalence and the suffering, dysfunction, morbidity and economic burden. It is estimated that by the year 2020, if current trends of demographic and epidemiological transition continue, the burden of depression increases to 5.7% of total burden of disease and it would be the second leading cause of Disability Adjusted Life Years (DALY) second only to ischemic heart disease.American Psychologists' Association has stated that the depressed individuals tend to feel helpless and hopeless, and blame themselves for having these feelings. People who are depressed become overwhelmed and exhausted and may stop participating in their routine activities. They may withdraw from family and friends. Some may even have thoughts of death and suicide.As a number of factors are involved in diagnosing depression, it is very difficult for a psychologist to diagnose it correctly. But, it is very important to diagnose the disorder earlier to prevent its worst outcome. The most widely used criteria for diagnosing depressive conditions are found in the American Psychiatric Associations revised Fourth edition of the Diagnostic and Statistic Manual of Mental Disorders (DSM-IV-TR) and the World Health Organization's International Statistical Classification of Diseases and Related Health Problems (ICD-10). ICD-10 and DSM-IV have many similarities in defining a disorder, but the structure of how the disorder is diagnosed is somewhat different. DSM-IV makes much more extensive use of diagnostic specifiers, while ICD-10 conceptualizes major depressive disorders as ranging from mild to severe with different symptom thresholds. DSM-IV provides for more specific inclusion and exclusion criteria which are not contained in ICD-10**[14].** ICD-10 is more stringent than DSM-IV and hence for efficient diagnosis, ICD-10 diagnostic criteria, symptoms, approach and threshold should be considered.

Ontology is a knowledge representation technique that provides a shared common understanding of a domain. It provides controlledvocabulary and helps in creating semantic web services and intelligent information retrieval. They can be created manually or automatically. Manual ontology creation consumes time but more efficient,while, automatic ontology creation can be constructed in less time but is less efficient.Hence, semi-automatic creation of ontologies are preferred than manual and fully automatic creation. Ontologies are used in various domains especially medical domain. Some of the Bio-medical ontologies are Gene Ontology (GO), Unified Medical Language System (UMLS), Human Disease Ontology, Protein Ontology, etc. Ontology has also been utilized in Psychology domain. But, full-fledged psychology ontology is not yet available. In spite of various advantages, ontologies do have some drawbacks. They are: (i) Ontology does not quantify the degree of overlap or inclusion between two concepts and (ii) it cannot support reasoning when only partial information about a concept or individual in the domain can be obtained.**[9].** The drawbacks of ontology have been

International Journal of Data Mining Techniques and Applications
Volume: 04 Issue: 02 December 2015 Page No.59-62
ISSN: 2278-2419

overcome by another knowledge representation technique called Bayesian Networks.

Bayesian Networks or Belief Networks (BN)areProbabilistic Graphical models used for reasoning under uncertainty [25]. The network has nodes to represent discrete or continuous variables and arcs to represent direct connections between them. These direct connections are often causal connections. BNs model the quantitative strength of the connections between variables, allowing probabilistic beliefs about them to be updated automatically as new information becomes available. It applies Bayes theorem to solve problems. Bayesian Networks Research started in 1980 and since 1990, they are used in medical decision making like predicting disease evolution and benefits of treatment **[7].** Bayesian Networks are rarely used in diagnosis and treatment of mental or psychological disorders as the domain is very complex. But, it helps to systematize domain expert knowledge and observed datasets through complex probabilistic diagrams. The networks map cause-effect relationship between key variables like causes, symptoms, etc. It may help the psychiatrist in decision making process of diagnosis and treatment planning.The objective of this paper is to propose a framework that incorporates Bayesian Network as the main knowledge representation technique in diagnosing the depression level and suggests treatments according to the patient details provided to the framework. It could be a useful tool for novice psychologists to understand all the necessary concepts related to depressive disorder and to support their learning process by showing the elements employed for the diagnostic and treatment-oriented decision-making process. The framework is only a tool for the psychologists and not a replacement for the psychologists.

II. RELATEDWORK

This section gives a brief description on how Bayesian Networks have been used in Psychology domain to diagnose various mental disorders. S.Mani et al. **,**proposed a model for predicting mental retardation in newborns so that treatments can be made at an early stage itself [22]. A Bayesian Network Model has been designed to analyze psychiatric patient data and identify the most significant factors that affect the patients and correlations between factors[8]. The mental disorder that was concentrated was Schizophrenia and the data have been gathered from a Romanian Specialty Clinic during a couple of years. Focus was given on using Bayesian Networks in assisting Social Anxiety Disorder diagnosis [11]. The network model was constructed manually based on domain knowledge and conditional probability tables were learned using Netica Software.Michael C.A.Kleinhas proposed an approach based on Bayesian Networks to model relationship between mental states and empirical observations in a depressed person[23]. It provides examples of how the network can be used to estimate mental states. In **[29]** a Bayesian Network was proposed to diagnose Schizophrenia mental disorder. It uses information concerning etiology, associated features and laboratory tests along with descriptive details of the disorder. AnshulSatsangi and Prof. RekhaSugandhi, have proposed a Bayesian Network and Semantic Network Model for better prediction treatment pattern for psychiatric disorders and improve the prognosis result which helps to know the future prediction of disorders Dementia and Alzhiemer.

F. Luiz, et al. have proposed a Clinical Decision Support System that diagnoses Dementia and its related disorders using Bayesian Network**[28]**. They constructed the network structure based on data from clinical cases.The clinical concepts were modeled using MLHIM-Multi-Level Health Care Information Model.Yue-Shan Chang, et al. has inferred the possibility of becoming depressed using Ontology and Bayesian Network**[6]**. They also implemented a prototype using Mobile-Agent Platform as a proof-of-concept in the mobile cloud. Concha Bielza, had surveyed key research in neuroscience where Bayesian Networks have been used with different aims: discover association between variables, perform probabilistic reasoning over the model, and classify new observations with and without supervision**[5],**. Thus, a lot of research works have been made on using Bayesian Networks in diagnosing mental disorders. Most of the research works concentrated on mental disorders like Schizophrenia, Dementia, Alzhiemer and Social Anxiety Disorders. But, there is no particular research work that diagnoses depression levels in adolescents using Bayesian Networks. This article presents a framework on using Bayesian Networks to diagnose depression levels among adolescents and suggests treatments for various levels.

III. FRAMEWORK FOR DIAGNOSING DEPRESSION LEVEL AMONG ADOLESCENTS

This section provides the framework that diagnoses depression level among adolescents and suggests treatments according to the patient details. The framework for diagnosing depression level has been given in Figure 1. The first step in the framework is to identify domain experts. As there are few numbers of psychologists for diagnosing adolescent depression, relevant documents are also reviewed to acquire domain knowledge.

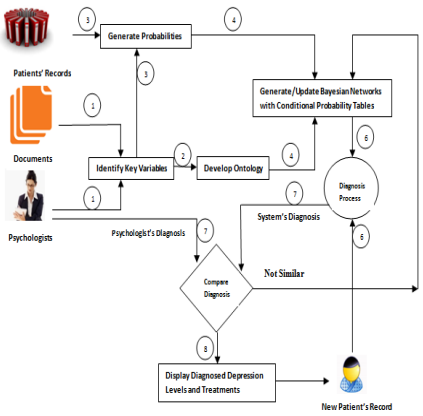

Figure 1: Bayesian Framework for diagnosing Depression Level among adolescents

Then the Knowledge Engineer has to identify the key variables/features for the particular domain. Next, the dependencies and semantic relationships between key variables are identified. Based upon these relationships between variables, Ontology for Major Depressive Disorder is constructed. The Ontology may be constructed manually or

International Journal of Data Mining Techniques and Applications
Volume: 04 Issue: 02 December 2015 Page No.59-62
ISSN: 2278-2419

automatically using some tools. The popular tool used to construct ontology is Protégé Editor. The figure below shows the Ontology created using Protégé Software and it provides us the topology for Bayesian Network.The next step in the framework is to specify the prior probabilities for each node and specify the conditional probability distribution for each intermediary and leaf nodes. The prior probabilities of each node are to be calculated using the statistics available in the patients' records and it should be confirmed with the domain experts. If needed, the probability values may be updated after consulting with the experts. A simple network has been given in figure 2 that considers two depressive symptoms (Extreme Sadness and Suicidal Thought) and three depressive disorders (Major Depression, Dysthmia and Post Partum Depression).

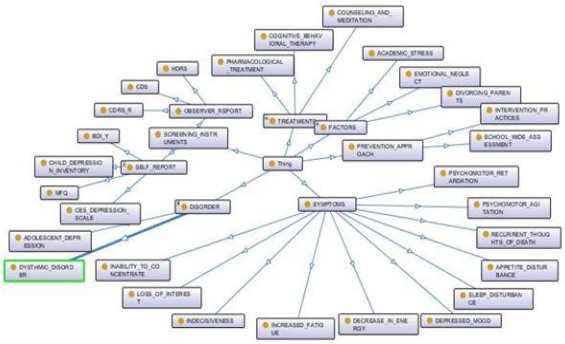

Figure 2 : Adolescent Depression Ontology created using 'Protégé' tool

These probabilities assigned to the arcs help us to quantify the relationships between the connected nodes. Now, construct the Bayesian Network using any Bayesian tool like Genie/Netica. The software automatically generates the Conditional Probability Tables, if the prior probabilities of each node are provided to the software. The Conditional Probability Table (CPT) for each node demonstrates the marginal probability of a single variable with respect to others.

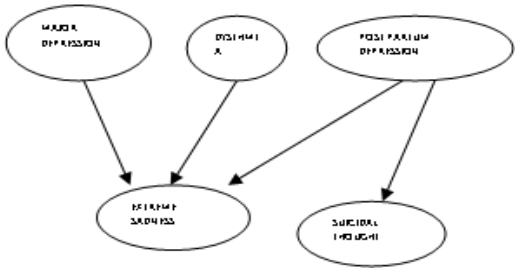

Figure 3 : Bayesian Network illustrating Depressive Disordersand its Symptoms

Sample probability values for each node of the above Bayesian Network are given in Table 1. This BN acts as the Knowledge-Base in this framework. Using Bayes Rule, the probability of Major Depression can be inferred given observations of other four nodes. The inferred probability of Post Partum Depression is **0.33886** while the prior probability of Post Partum Depression is 0.3 (over 112 times as probable**)**.Before the Bayesian Network Model can be used in real life for diagnosis, they have to be extensively evaluated.

Table 1 : Probabilities for the variables in Figure 3

PROBABILITY		Conditions		
		Major Depression	Dysthmia	Post Partum Depression
Major Depression : Yes	Major Depression : No	-	-	-
0.00001	0.99999			
Dysthmia : Yes	Dysthmia : No	-	-	-
0.25	0.75			
Post Partum Depression : Yes	Post Partum Depression : No	-	-	-
0.3	0.7			
Suicidal Thought : Yes	Suicidal Thought : No	-	-	-
0.2	0.8	-	-	Yes
0.01	0.99	-	-	No
Extreme Sadness : Yes	Extreme Sadness : No			
0.095	0.905	No	No	No
0.0001	0.9909	No	No	Yes
0.003	0.597	No	Yes	No
0.0002	0.9998	No	Yes	Yes
0.998	0.002	Yes	No	No
0.9995	0.0005	Yes	No	Yes
0.25	0.75	Yes	Yes	No
0.37	0.63	Yes	Yes	Yes

An example set of one unknown and four observations from depression network in Figure 3. Values are observed for every variable exceptPost Partum Depression. These observed values can then be used to give an updated probability for the belief of Post Partum Depression being Yes.

Table 2

Variable	Extreme Sadness	Suicidal Thought	Major Depression	Dysthmia	Post Partum Depression
Value	Yes	No	Yes	Yes	?

Before the Bayesian Network Model can be used in real life for diagnosis, it has to be extensively evaluated. The goal of evaluation is to determine how well the model diagnoses the depression levels and suggests correct treatments. It also determines how often this model incorrectly diagnoses depression levels and suggests treatments. To evaluate the constructed Bayesian Network, let us have a set of patients' records whose depression levels have been correctly determined and correct treatments were proposed by expert psychologists. Using these records, the Bayesian Network is then queried with the patient's data for diagnosing the depression level and for suggesting treatments. Thus the quality of the framework could be determined as a function of how well the diagnoses made by the framework agree with the diagnoses made by the experts. If the quality of the framework is above a threshold value, then it could be employed to query with new patients details. Some of the queries it can answer are:

- What is the probability of a patient having high depression level given the symptoms?
- What are the probabilities of the causes of depression if depression level and different symptoms are given?
- What is the probability of using a particular treatment given the patient's depression level and symptoms?

IV. CONCLUSION

This article proposed a framework that incorporates Bayesian Network as the main knowledge representation technique in diagnosing the depression level and suggests treatments

International Journal of Data Mining Techniques and Applications
Volume: 04 Issue: 02 December 2015 Page No.59-62
ISSN: 2278-2419

according to the patient details provided to the framework. The Bayesian Network is an effective Technique for Knowledge Representation and inference under uncertainty. It systematizes domain expert knowledge and observed datasets of patients and helps to map cause-effect relationship between key variables. The ontology that provides the topology to BN could be a useful tool for novice psychologists to understand all the necessary concepts related to depressive disorder and to support their learning process by showing the elements employed for the diagnostic and treatment-oriented decision-making process. The framework can only be used as a tool for the psychologists and not as a replacement for the psychologists. This paper has provided only a framework which has not been implemented in real life situations. The main limitation of this framework is in identifying key factors of depression. As a large number of factors are involved in depression, the BN becomes larger and so the conditional probability tables will also become larger. Still, more research is needed in identifying factors of depression. In future, this framework may be implemented in real life situations. If implemented it really assists the psychologists in a big way to diagnose the adolescent depression at an early stage. The early diagnosis helps to identify depressed adolescents and treatments may be provided to avoid unexpected outcomes like suicide.

REFERENCES

[1]Ahmed, MobyenUddin. A case-based multi-modal clinical system for stress management.School of Innovation, Design and Engineering, Mälardalen University, 2010.

[2] Ahmend, MobyenUddin, et al. "Case-based reasoning for diagnosis of stress using enhanced cosine and fuzzy similarity." Transactions on Case-based Reasoning for Multimedia Data 1.1 (2008): 3-19.

[3] Andrews, Gavin, et al. "Dimensionality and the category of major depressive episode." International journal of methods in psychiatric research 16.S1 (2007): S41-S51.

[4] AnshulSatsangi, RekhaSugandhi. "Clinical Decision Support System for Psychiatric Disorders" International Journal of Engineering Research & Technology (IJERT). ISSN: 2278-0181. Vol. 3 Issue 12, December 2014

[5] Bielza C., Larrañaga P. "Bayesian networks in neuroscience: a survey". Front. Comput.Neurosci. 8:131. 10.3389/fncom.2014.00131. 2014.

[6] Chang, Yue-Shan, et al. "Mobile cloud-based depression diagnosis using an ontology and a Bayesian network." Future Generation Computer Systems 43 (2015): 87-98.

[7] Curiac, D-I., et al. "Bayesian network model for diagnosis of psychiatric diseases." Information Technology Interfaces, 2009. ITI'09.Proceedings of the ITI 2009 31st International Conference on.IEEE, 2009.

[8] Curiac, D-I., et al. "Bayesian network model for diagnosis of psychiatric diseases." Information Technology Interfaces, 2009. ITI'09.Proceedings of the ITI 2009 31st International Conference on.IEEE, 2009.

[9] Ding, Zhongli, and Yun Peng. "A probabilistic extension to ontology language OWL." System Sciences, 2004.Proceedings of the 37th Annual Hawaii international conference on.IEEE, 2004.

[10]Ekong, Victor E., Udoinyang G. Inyang, and Emmanuel A. Onibere. "Intelligent Decision Support System for Depression Diagnosis Based on Neuro-fuzzy-CBR Hybrid." Modern Applied Science 6.7 (2012): p79.

[11] Estabragh, ZakiyehShojaei, et al. "Bayesian network modeling for diagnosis of social anxiety using some cognitive-behavioral factors." Network Modeling Analysis in Health Informatics and Bioinformatics 2.4 (2013): 257-265.

[12]Estabragh, ZakiyehShojaei, et al. "Bayesian network modeling for diagnosis of social anxiety using some cognitive-behavioral factors." Network Modeling Analysis in Health Informatics and Bioinformatics 2.4 (2013): 257-265.

[13]Gartner, Joseph, et al. "Psychiatric diagnosis from the viewpoint of computational logic." Computational Logic—CL 2000.Springer Berlin Heidelberg, 2000.1362-1376.

V. [14] Gruenberg, A. M., Goldstein, R. D. and Pincus, H. A. (2005) Classification of Depression: Research and Diagnostic Criteria: DSM-IV and ICD-10, in Biology of Depression: From Novel Insights to Therapeutic Strategies (eds J. Licinio and M.-L. Wong), Wiley-VCH Verlag GmbH, Weinheim, Germany.doi: 10.1002/9783527619672.ch1

[15] Hadzic, Maja, FedjaHadzic, and Tharam Dillon. "Tree mining in mental health domain." Hawaii International Conference on System Sciences, Proceedings of the 41st Annual.IEEE, 2008.

[16]Hadzic, Maja, Meifania Chen, and Tharam S. Dillon."Towards the mental health ontology." Bioinformatics and Biomedicine, 2008.BIBM'08.IEEE International Conference on.IEEE, 2008.

[17] Im, Y. H., et al. "A KFD web database system with an object-based image retrieval for family art therapy assessments." The Arts in Psychotherapy 37.3 (2010): 163-171.

[18] Kim, S. I., et al. "A framework for expert system knowledge base in art psychotherapy." Expert systems research trends (2007): 181-206.

[19] Haghighi, Mojgan, et al. "Development of clinical ontology for mood disorder with combination of psychomedical information." J Med Dent Sci 56.1 (2009): 1-15.

[20] Heckerman, David. A tutorial on learning with Bayesian networks.Springer Netherlands, 1998.

[21]Major Depressive Disorder. Wikipedia, Web. http://en.wikipedia.org/wiki/Major_depressive_disorder

[22]]Mani, Subramani, Suzanne McDermott, and Marco Valtorta. "MENTOR: a bayesian model for prediction of mental retardation in newborns." Research in Developmental Disabilities 18.5 (1997): 303-318.

[23]Michel C. A. Klein, and Gabriele Modena. "Estimating Mental States of a Depressed Person with Bayesian Networks."Contemporary Challenges and Solutions in Applied ArtificialIntelligenceStudies in Computational Intelligence Volume 489, 2013, pp 163-168

[24]Milton, Nick, David Clarke, and Nigel Shadbolt."Knowledge engineering and psychology: Towards a closer relationship." International Journal of Human-Computer Studies 64.12 (2006): 1214-1229.

[25] Neapolitan, Richard E. Learning bayesian networks. Vol. 38. Upper Saddle River: Prentice Hall, 2004.

[26]Nunes, Luciano C., Plácido R. Pinheiro, and Tarcisio C. Pequeno. "An expert system applied to the diagnosis of psychological disorders." Intelligent Computing and Intelligent Systems, 2009.ICIS 2009. IEEE International Conference on.Vol. 3.IEEE, 2009.

[27] Pinheiro, PlácidoRogério, A. Castro, and M. Pinheiro. "A multicriteria model applied in the diagnosis of Alzheimer's disease: a Bayesian network."Computational Science and Engineering, 2008.CSE'08.11th IEEE International Conference on.IEEE, 2008.

[28]Seixas, FlávioLuiz et al. A Bayesian network decision model for supporting the diagnosis of dementia, Alzheimer's disease and mild cognitive impairment. Computers in Biology and Medicine , Volume 51 , 2014.140 - 158

[29] Sorias, Soli. "Overcoming the limitations of the descriptive and categorical approaches in psychiatric diagnosis: a proposal based on bayesian networks."

[30] Stephenson, Todd a. "An introduction to bayesian network theory and usage."idiap-rr 00-03 (2000).

[31]A Bayesian Network Decision Model for supporting the diagnosis of Dementia, Alzhiemer's Disease and Mild Cognitive Impairment – 2014

[32]Yap, R. H., and David M. Clarke."An expert system for psychiatric diagnosis using the DSM-III-R, DSM-IV and ICD-10 classifications." Proceedings of the AMIA Annual Fall Symposium.American Medical Informatics Association, 1996.