Development of a Diagnostic Expert System for Autism Disorder-PCADEX

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Abstract

Autism is a neurodevelopment, psychological and behavioral disorder. It is a childhood disorder and diagnosing autism is a major issue as its symptoms can easily be confused with those of mental retardness. Successful intervention requires correct diagnosis. As the major issue faced in Pakistan is of proper diagnosis of the autistic children who are mostly misdiagnosed as mentally retarded and thus are unable to get the required treatment which can enable those children to live like a normal child. Despite autism being a major area of concern worldwide, no remarkable work is done in Pakistan as yet. The diagnoses of autism currently being done in Pakistan is based on manual procedures. It is the need of time to have automated systems for diagnosing these disorders instead of doing them manually. Therefore, we developed an expert system, on the requirement of the clinical psychologist, which can act intelligently and correctly diagnoses the subject on the basis of the characteristics/symptoms. It is an interview based system which works on the basis of the behavioral characteristics of autism that are incorporated into the system in the form of rules and facts. Rules and facts make the knowledge base of the system from which the decision is extracted by the inference engine depending on the user's data input. The result is generated on its basis that categorizes the subject as having autism or not and classifies the level of autism present. This expert system will facilitate the clinicians and the related professionals in diagnosing this disorder. And will also open new horizons for the further developments for autism in Pakistan.

1. Introduction

Autism is defined with different terminologies such as a neurodevelopment disorder, neuropsychological disorder and behavioral disorder. Neurodevelopment disorder means that there is developmental deficit in those brain regions which are responsible for the normal child behaviors. Thus the individual with autism has behavioral, social and communication impairments. [1] Neuropsychological and behavioral disorder terminologies are also often used to describe autism in which there is impairment in the socio-cognitive skills and hence abnormal behaviors are observed in these affected individuals. [1]

Autism is diagnosed based on the presence of certain behaviors & communication level either directly observed or more typically reported during parental interview. [7] There is no biological test to diagnose autism, depending on the history and neurological examination; tests are prescribed to the affected persons [1].

Many of the screening and diagnostic tools have been made for the diagnosis of autism but most of these tools are able to detect the syndrome by the age of 18 months and a reliable detection can be made around three years of age [22]. And no instruments can reliably detect the syndrome in first 6-12 months of life because all of these instruments mainly focus on the behavioral attributes of autism which are not shown until age one year.

The major tests/tools or systems that are being used worldwide are:

Autism Diagnostic Observation System (ADOS) and Autism Diagnostic Interview (ADI) are the most comprehensive diagnostic systems for diagnosis. These systems take detailed interview from the individuals and provide observation methods to objectively assess the social, communication and behavioral abilities of the individuals [1].

Checklist for Autism in Toddlers (CHAT) is a brief checklist with good discriminating capacity screening for autism and this tool was very useful as it gave low rate of false positive results [22].

Childhood Autism Rating Scale (CARS) is the best validated instrument for diagnosis of ASD's (Autism spectrum disorders). It is based on behavioral interview and observations [22].

Autism Treatment Evaluation Checklist (ATEC) is an online form which diagnoses autism and also evaluates the treatments progress.

There are a wide range of diagnostic tools developed using artificial neural network (ANN) techniques for the identification of autism. These ANNs consists of synapses which are assigned weights, and of neurons. They are used for information processing after they have learned

and have been trained from typical examples and thus helping in diagnostic purposes e.g.

Self-Organizing Maps (SOMs) are artificial neural networks that are used to develop cortical feature maps [23].

Non-linear pattern recognition system based on neural network technology is used for the classification of autism.

Developmental behavior check list neural network (DBC NN) is a diagnostic system which assesses behavioral and emotional problems in children and adults with a developmental disorder from age 2 to 18 years.

A neurofuzzy based model is also used for the identification or diagnosis of autism.

An expert system called as Knowledge Base Screener is also developed for the early identification of autism in children. The screener is simple and effective method of analyzing child's development and it also help parents in early identification of any developmental disorder [28]. This system was specifically made to target the Indian masses and its marketing is limited to India, not available internationally for general use.

Artificial intelligence (AI) techniques have been usefully employed in bioinformatics and also provided solution to many biological problems. One of the largest areas of applications of artificial intelligence is in Expert Systems also known as knowledge based systems. Expert system makes extensive use of specialized knowledge to solve problem at the level of human expert. Expert system consists of two main parts: the knowledge base and the inference engine. The knowledge base contains all the knowledge on the basis of which inference engines draws conclusion. It contains heuristic knowledge and factual knowledge. Factual knowledge is the knowledge extracted from books, journals and magazines whereas heuristic knowledge is based on one's judgments. Some inferences (facts) are also made by expert system in the same way that a human expert would reason the solution to a problem.
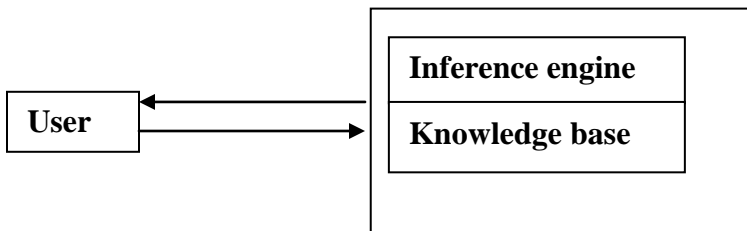

Fig 1.2: Basic function of expert system

The user supplies the desire information to the system and the expert systems acts intelligently and gives response to the user. The knowledge base is designed such that it acts like an intelligent assistant to the human expert. The more knowledge expert system holds the more efficient it is.

2. Development of a diagnostic expert system in Pakistan

Due to the advantages and the need of an expert system we are developing an interview based autism diagnostic expert system 'PCADEX' abbreviated as Pakistan Childhood Autism Diagnostic Expert System. The knowledge base of the expert system is based on the expert's knowledge of the particular domain.

We used ATEC questionnaire with the different approach. We have incorporated the artificial intelligence techniques on it and molded the questions in a way that the number of questions being asked depends on the category (normal, borderline, mild to severe, severe) to which the subject seems to belong i.e. the subject who is more towards autism will have to answer more questions so as to judge the level of autism correctly whereas the subject with normal characteristics will only have to answer a few set of questions and thus system concludes intelligently like a human expert.

The implementation of ATEC questionnaire was first done in Dev C++. This program was made using the hard computing i.e. values are assigned to individual options which add up to the current score according to the option selected. The program categorizes the subject as normal, borderline, mild and severe autistic. This was an interview based diagnostic system which asks the complete set of 77 questions from every user irrespective of the category (i.e. normal, borderline, mild and severe autistic) he/she belongs. This works on the scoring methodology i.e. if the score is <56.59 than the subject is normal, if score is 56.6 – 57.4 than the subject will be borderline autistic, if the score is 57.5-59 than the subject is mild autistic and if the score is > 59 than the subject is highly autistic.

3. Development of PCADEX using PROLOG

Prolog is the highest level general purpose language involving human reasoning. It is declarative language because all program statements are definitional. It strongly emphasizes on the logical relations between the entities of any given problem. The relationships between the entities/data members are defined then and on there basis the system decides the way to solve a problem. The logical program consists of explicit facts and rules to define relations, on the basis of which the implicit knowledge can be gained. This language is majorly used for data base interfaces, expert systems, and mathematical theorem provers. This language best suited our problem as we were developing an expert system which required declarative programming in which we can define our problem in the form of rules.

The ATEC questionnaire was the baseline of our project. We organized the set of questions in a way, forming blocks for the same type of questions with one

major and varying minor question and then designed the rules on the basis of blocks. From the 77 questions of the ATEC criterion we merged the questions with same meaning and reduced them to a set of 54 questions with 16 major and 38 minor questions. Each question is comprised of three options that the user can opt 'N', 'S', 'V' for not true, somewhat true and very true respectively. Rules were made applying permutations and combinations for all the questions and their respective options, using the key provided by the expert (clinical psychological). Four different paths were created that draws a conclusion that whether the subject has autism or not and if yes then to which category it may belongs to i.e. borderline, mild or severe autism.

The system works with its integrated knowledge base in PROLOG. The knowledge base contains a set of rules and facts on the basis of which the inference engine draws a conclusion. The knowledge base of the expert system contains the facts that are based on the expert's knowledge. From those facts the rules were created in which we defined four different paths using statistical techniques i.e. permutations and combinations. In which all the possible options for a question are linked to all the options of next question creating four pathways from the dataset.

The pathways generated using rules provides the flexibility to the user, as it allows the reduction and expansion of the set of questions being asked, depending on the user's data input. The system will ask a minimum set of 16 questions for a normal subject, it decides on the basis of initial input to which path it has to lead. Whereas the number of questions increases as the severity level increases as the number of questions being asked are directly proportional to the subject's autism severity level.
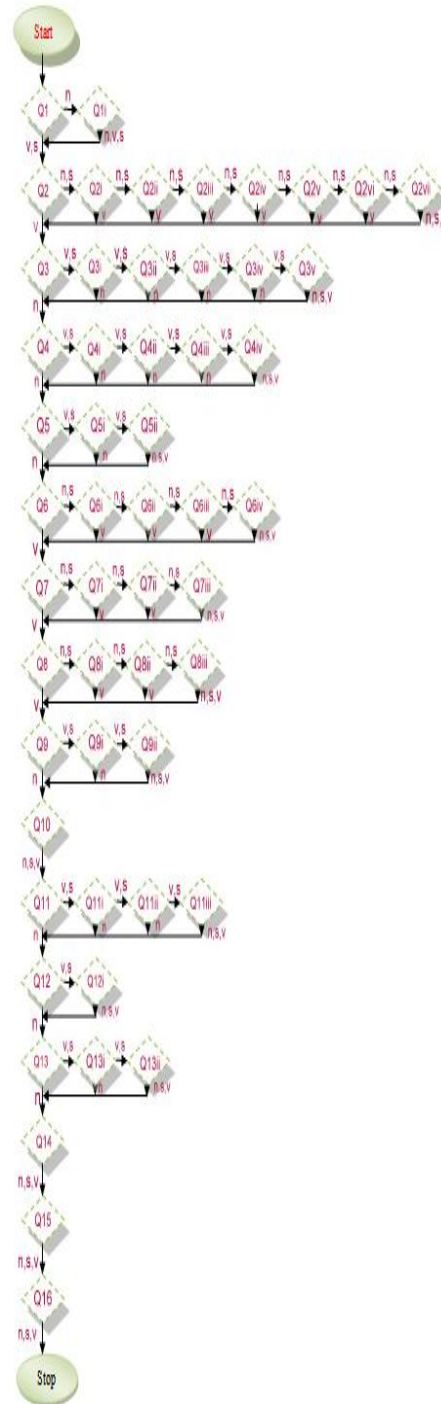
The flowchart in fig 2 is the representation of our system. The problem that was required to be solved is implemented successfully, using the automata, rules, and flowcharts into the PROLOG program that diagnoses the subject of being autistic or not and places him the respective category according specification provided.

4. Conclusion

The objective behind this project was to develop an automated system for autism diagnosis that can overcome the issues faced in Pakistan. This has been achieved successfully with the development of PCADEX. After the system was developed it was further tested and validated with the real subjects to determine its accuracy of results.

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