

Intelligent Autism Screening Using Fuzzy Agent



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Abstract In the diagnosis of diseases, either physical or psychological, there are situations causing reaching for second independent opinion very hard. This is especially true in the diagnosis of Autism due to the complex process of diagnosis. Apart from the complex process, the challenges include cost and the availability of experts. This, however, does not change the fact that having regular independent second opinions is crucial. Hence, this study proposes an intelligent autism screening model using fuzzy agent, to assist the expert and non-expert in making the diagnosis. In this study, the fuzzy inputs are assigned based on five categories, which are Communication, Gross Motor, Fine Motor, Problem Solving, and Personal Social, and is specifically for three-year-old children only. The proposed model will be able to produce output in the form of sequences based on lowest to highest mark of the scores for each category. This output will then relate to the suggestion of activities to autistic children by priority (based on the scores obtained).

Keywords Autism spectrum disorder (ASD) · Agent-Based · Fuzzy agent · Autistic children · Symptoms

1 Introduction

Autism or Autism Spectrum Disorder (ASD) is a common psychological disorder that affects 1 in 500 children [1]. It often remains undetected until after-toddlers age due to the difficulty in making the diagnosis, although in most cases, parents are aware that something is missing in the child development. The tool for diagnosis is not easily available, even if it is, it needs an expert's knowledge to interpret the result.

In most cases, the diagnosis of autism is not made until the two to three years because only then, the symptoms become obvious and the child starts to struggle to fit in the society. For children with ASD, being identified early has many advantages

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and most likely will also improve the outcome as intervention and treatment can be done early [1]. Every ASD child is unique because each exhibits their impairments (or sometimes extraordinary skills) in unique combinations [2]. The impairments are usually both on physical and psychological developmental delays. Apart from that, ASD children are also usually troubled by sound, touches, or smells which seem normal to others [3].

At the beginning of autism disorder, early intervention allows early educational and developmental planning, prepares the family for supports, stress management, education arrangement, and also ensure delivery of appropriate medical care and treatment [1]. For the intervention (in the form of therapies) to happen, a child needs to be assessed or diagnosed firstly, and for that matter, an early diagnosis is very important, especially for those with learning disabilities [4–6]. However, as important as it is, the prediction of autism disorder is difficult than a prediction of disease because it relates to a variety of attributes [3], where the main challenges are imprecision, uncertainty, and vagueness [7–12].

2 Related Works

Diagnosis of autism have been done by using certain sets of questions that are answered by parents or guardians, and based on the score values, the child will be able to be identified as having autism disorder or not. The diagnosis involves assessment of behaviors and usually takes several hours to complete [13]. Many established diagnostic tool (questionnaires) have been published, among them are Modified Checklist for Autism in Toddlers (M-CHAT) and Childhood Autism Rating Scale (CARS). M-CHAT diagnosis results have been doubted by [14]. However, this is especially the case for children born very preterm. In their critical review, state that the instrument (CARS) may not be applicable for those with sensory and intellectual disabilities [15]. They also suggested that for this group of people, additional diagnosis instrument is needed.

Another established diagnostic screening tool is The Ages and Stages Questionnaires, 3rd edition (ASQ-3[®]) [16], which is developed for monitoring children in the age range of 2–60 months. This tool evaluates five elements such as communication, gross motor, fine motor, problem-solving, and personal-social, where each section consists of several questions to be completed by parents.

This method of diagnosis using established questionnaires, for the fact that it involves many questions and the results are not easily translatable by people of non-experts, make the diagnosis process lengthy and nearly impossible to be done without the presence of experts. There have been several studies done on proposing a diagnostic tool (system) to replace the lengthy questionnaires. However, most of them only diagnose the level. For example, Ahuja, R. and Kaur, D. developed a diagnosis method using neuro-fuzzy, but the diagnosis output is only either high (high level of autism) or low (low level of autism) [3]. To come out with this very simplified result, the extensive questionnaires still need to be answered to get the

score as input to their neuro-fuzzy system. This method is not, in any way helping in shortening or simplifying the process of diagnosis.

Two attempts to shorten the process of diagnosis have also been made [17, 18]. However, these two attempts have been criticized for not proving significant time reduction in the diagnosis process [19]. Al-diabat, M. then, suggested a fuzzy rule-based model consisting of 24 variables to diagnose children at the range of age between 4 to eleven years old [19].

Tariq, Q. proposed a solution to the lengthy and complicated process of diagnosis. He suggested the use of a 3-minute home video to assess the behaviors of an affected child where the video is shared in their established web portal and then rated by non-expert raters [13]. The non-expert raters will then assess the video by looking at certain characteristics such as eye contact, communication, etc. This method, although it can be considered as a very good alternative for diagnosis without the presence of experts, it is, however, again not in any way simpler because it needs an established platform and participation from the public. The result also very much relies on humans' opinion.

Being able to diagnose only the level of autism is useful but not quite enough. For the focused therapy to happen, the exact area (problem) must be determined. Knowing one is having severe autism is not enough, but knowing in which area the patient has a major problem with (communication, personal, social, behavior etc.) is very important. Based on the review on existing studies, apart from attempting to simplify the process of diagnosis, none of the works have attempted for detail diagnosis (diagnosing category) as well as the suggestion of therapy activities.

3 Methodology

3.1 Overview of Fuzzy Agents

This research applies fuzzy agent to classify human behavior of autistic children. Intelligent agents can perform flexible and independent autonomic actions to accomplish goals that have been set through computer systems. The agent will receive input and then it will act to change the environment.

According to [20], in most agent-based systems, the behavior of an agent that interacts with other agents of the system is composed of three phases, (1) receives information from another agent or perceives a change in its environment, (2) interprets the event and decides on actions to be performed by taking into account other agents, (3) sends a message or performs an action to modify the environment.

The agents, that implement ambiguous problems through fuzzy logic, are called fuzzy agents [21]. In their study, [22] provided fuzzy agents that can decide for more effective design when fuzzy design information is considered in a fuzzy interaction. As shown in Fig. 1, observe, decide, and act are the elements in the fuzzy agent. It can be applied for autism screening in this research, by providing input from

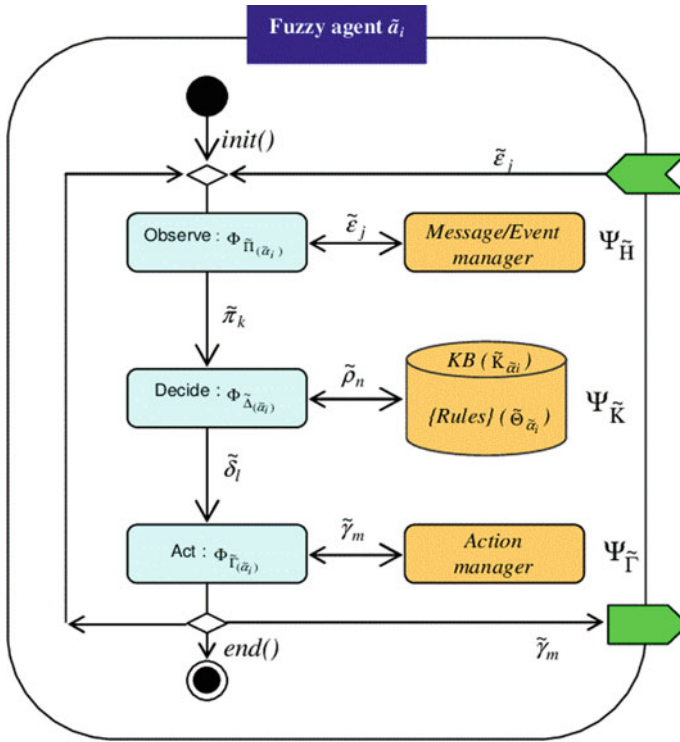


Fig. 1 Functional architecture of a fuzzy agent [20]

questionnaires (observe), then the autism challenges will be categorized in a specific category (decide). Finally, the fuzzy-agent-processed output known as activities (act) will be proposed as guidance or suggestion for autistic children specifically.

3.2 The Working Mechanism of Fuzzy Agent for Autism Screening

In the proposed model for this Intelligent Autism Screening, four processes are needed to produce data and get output using questionnaire data based on autistic parent responses, as demonstrated in Fig. 2.

Step 1. **Data Collection.** Autistic children data will be provided by parents through established questionnaires. This process will be assisted by Occupational Therapy (OT) from several Autism therapy centers in Malaysia. The data will then be pre-processed before being used as input for the next step.

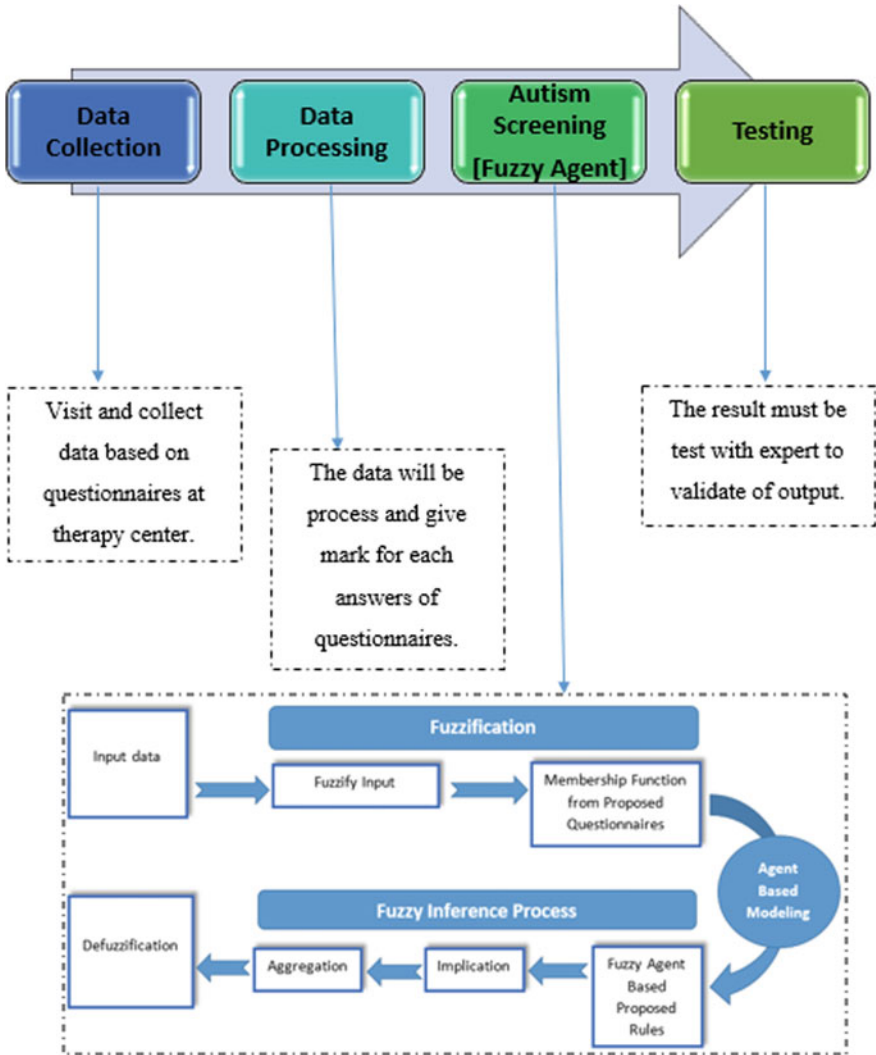


Fig. 2 The framework of intelligent autism screening diagram

- Step 2. **Data Processing.** All data from the questionnaire is processed before being fed into fuzzy rules. The output at this stage is mark/rating for each category involved and will use as input for the next process.
- Step 3. **Autism Screening using Fuzzy Agent.** After data is processed, the data will be fed into fuzzy-agent based model to obtain the final output, which is the suggestion of therapy activities.

Step 4. **Testing.** The results will be verified by experts (occupational therapies) to validate whether or not the developed model has provided a valid output, which is the suggestion of therapy activities based on ASD level of the child.

4 Results and Discussion

Figure 3 shows the agents involved, where the numbering of agents represents the rank of marks in order. Each agent will represent one category where in this case there are five categories: Communication, Gross Motor, Fine Motor, Problem Solving, and Personal-Social.

In Phase I, the rank marks are the output obtained from the questionnaires marks that have been fed through fuzzy rules. The output from this stage (rank of categories) will be fed through the next fuzzy agent-based model in Phase II. In Phase II, the fuzzy agent-based model will consider the three top categories (three highest marks from Phase I) as variables.

The example of fuzzy rules involved in Phase I is provided in Table 1 and the linguistic value and notation are provided in Table 2. The rules in Table 1 represent an only small part of the rules involved where one rule indicate one ASD child. For example, Rule 1 can be interpreted as follows:

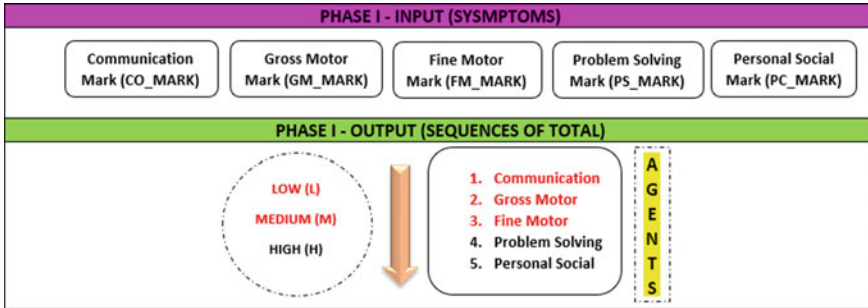


Fig. 3 Modeling of agent-based with input and output for phase I

Table 1 Rules of input and output from phase I

Rule	CO_MARK	GM_MARK	FM_MARK	PS_MARK	PC_MARK	Activity
1	MR(1)	RE(4)	MR(2)	NR(5)	MR(3)	C
2	RE(3)	RE(4)	NR(5)	MR(1)	MR(2)	B
3	NR(2)	NR(3)	NR(4)	NR(5)	MR(1)	A
4	NR(4)	RE(2)	NR(5)	MR(1)	RE(3)	D
5	RE(3)	MR(1)	MR(2)	NR(4)	NR(5)	E

Table 2 Linguistic value and notation

Symptoms	Label	Status	Label
Low	L	Most required	MR
Medium	M	Required	RE
High	H	Not required	NR

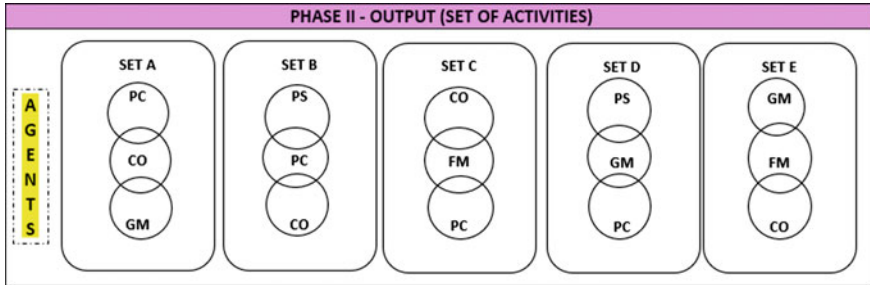


Fig. 4 Modeling of agent-based with input and output for phase II

If communication mark (CO_MARK) is low,
 AND gross motor mark (GM_MARK) is medium
 AND fine motor (FM_MARK) is low and
 problem-solving (PS_MARK) is high
 AND personal social (PC_MARK) is low
 THEN Activity is C.

According to the agents in Fig. 4, Activity C is the combination of ‘fine motor’ (FM) with ‘communication’ (CO) and also FM with ‘personal-social’ (PC). This result indicates that based on the scores of ASD child number 1 (Rule 1), the suggested activity is the activity involves with ‘fine motor’. The improvement in ‘fine motor’ will affect positively also on communication and personal-social.

Figure 4 shows five sets of agents that work in Phase II, in which each agent has one dominant variable. For example, agent Set A has CO as dominant variable meaning that if an ASD child is pointed to this agent (based on the scores from the questionnaire), the suggestion of therapy activity is focused mostly on communication associated with gross motor and personal-social. Agent Set B is focused on personal social activity that is associated with problem-solving and communication; agent Set C is focused on fine motor that is associated with communication and personal social; agent Set D is focused on gross motor that is associated with problem-solving and personal social; and agent set E is focused on fine motor that is associated with communication and gross motor.

5 Conclusions

Based on the proposed fuzzy agent-based model, an intelligent screening tool will be developed. One fully functional screening tool will be able to diagnose the level of severity and category, and also come out with the suggestion of suitable therapy activities. This tool will be a great help for parents and also trainee experts. However, the result must be verified and validated by the experts in the field.

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