Fuzzy Logic for Autism Screening Test.

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Abstract. Autistic Spectrum Disorder (ASD) can faze brain development, growth, and social behaviour. Teens with ASD tend to become bullying object. Autism can be recognized and diagnosis using a test with a questionnaire. The answers from the questionnaire usually converted into an integer value using the Linkers scale, whereas this answer still contains biased and this bias cannot be captured using this scale. Through our initial test results shows that if a user uses an answer choice slightly agree or slightly disagree, the results value is low enough it's about 6% to 20%. Autistic according to the CDC, it has eight symptoms, and we apply it to form fuzzy memberships. Previous Researchers had been shared autism screening dataset to the UCI machine learning repository, this dataset we filtered for "Who is completing the test" attribute with "self" value. We used the classification algorithms in WEKA to find a model, then this model we applied in fuzzification. This system is still a simulation study and has not been clinically tested. This system is assigned to diagnose autism based on the recognized symptoms, where the number of asked questions can vary according to needs but still refers to the symptoms. This paper proposed an autism screening test diagnosis using the fuzzy logic with a better interpolation and precision.

1. Introduction

Autistic Spectrum Disorder (ASD) is a symptom that may occur from two-year ages and can last a lifetime [1]. Autism disrupts brain to evolve so that people with autism his/her social behavior and communication will be limited compared to the others [2], have a repetitive anomaly behaves and stereotypically [3][4].

The ASD level in the last 40 years is increasing about 10 times [5]. Statistics data at 2005 shows a motor accident rate high enough about 14% in adolescents with autism [6]. Other important issues for people with ASD especially teenagers are getting higher get bullying behaviour from his/her friends than the other [7]. Based on the Centres for Disease Control and Prevention (CDC), autism has eight symptoms: Intelligence, Social Interaction, Communication, Behaviours, Sensory (Pain & Sound) and Motor (Fine & Gross) [8].

Research on autism for adolescents and adults less than a child. Question for every screening test number is quite a lot. Previous research has proposed a reduced number of questions and shares his dataset at UCI [9]. Based on our findings of autism data in the UCI, it has a weakness for autism screening test because:

1. The statement submitted in each session is the same and do not represent the whole autistic symptoms.
2. Diagnostics based on the total score. Answer from a user which is reflected as autism has value 1. If the total scores ≥ 7, then the user will be counted as autistic.

3. If the answer is chosen slightly agree or slightly disagree for every 100 times experiment then the results are, for the adult, there were 20 diagnosed as autistic, and for adolescents, it drastically decreased to 6.

A screening test is generally in questioner form with the answer that was measured using a Linkers scale. Linkers scale often associated with opinions/values/rating on the questionnaire, and this scale equalizes the value of the respondent's answers [10] [11]. Answer using this scale is still allowing the existence of bias, IE: central tendency bias, acquiescence response bias or social desirability bias [12]. The response given to this scale is an integer and the level of response of which can still be discrete [13].

In this paper, we proposed an application for autism screening test using CDC autism symptoms and Fuzzy logic. CDC symptoms can use as questions container on the existing screening methods. Fuzzy chosen because it can facilitate human answer that tends to be vague or fuzzy and moderate interpolation answers bias on a Linkers scale.

2. Research Method

This research use Fuzzy Logic framework wherein the fuzzifier process using CDC autism symptoms to form of the memberships. The process for fuzzy rules generation we use third applications, named FISPRO. On the defuzzification process we use the model of autistic though UCI dataset which has been filtered and tested using WEKA, test results can be seen on our project [14] in https://osf.io/M6G3N/. Our test results show that the value of the others attributes has no effect on the classification except "Result" attribute.

Data from the UCI dataset for adolescent and adult data there are 104 and 704 data, from both dataset, the data is extracted only for attribute "Who is completing the test" with "self" value. Testing using 16 classification algorithms, with pre-process data totalled 564 without duplicates. The data is split down with composition 60% data training, 20% cross-validation, 20%, and 20% testing. ZeroR Algorithm use as the baseline accuracy, with a value of baseline accuracy of 70.4142.

Fuzzy membership type use in this paper is trapezoidal. This type of membership is easy to describe in statistical computations [10]. This paper framework is in Fig.1 Fuzzy logic for autism screening test workflow.

![Figure 1 Fuzzy logic for autism screening test workflow](image-url)
3. Result and Discussion

3.1 Fuzzification

The comparison results between the questions used in the [14] data with autism symptom from CDC. For the adult test: there is 1 question for sensory, 5 questions for intelligence, 2 questions for communication, and 2 questions for social interaction, for adolescents: 2 questions for intelligence & social interaction, 6 questions 1 question for a motor, and 1 question for communication. Comparison Results show that not all symptoms for autism diagnosis included on each test. Memberships parameter used in this paper is:

[Input1]
Name='Intelectual'
Range=[ 0.000 , 1.000 ]
MF1='Gifted','SemiTrapezoidalInf',[ 0.000 , 0.600 , 0.800 ]
MF2='Disability','SemiTrapezoidalSup',[ 0.600 , 0.800 , 1.000 ]

[Input2]
Name='SocialInteraction'
Range=[ 0.000 , 1.000 ]
MF1='VarietyOfFrivenships','SemiTrapezoidalInf',[ 0.000 , 0.600 , 0.800 ]
MF2='NotInterestToTheOthers','SemiTrapezoidalSup',[ 0.600 , 0.800 , 1.000 ]

[Input3]
Name='Communication'
Range=[ 0.000 , 1.000 ]
MF1='Verbal','SemiTrapezoidalInf',[ 0.000 , 0.700 , 0.900 ]
MF2='NonVerbal','SemiTrapezoidalSup',[ 0.700 , 0.900 , 1.000 ]

[Input4]
Name='RepetitiveBehaviours'
Range=[ 0.000 , 1.000 ]
MF1='Mild','SemiTrapezoidalInf',[ 0.000 , 0.700 , 0.900 ]
MF2='Intense','SemiTrapezoidalSup',[ 0.700 , 0.900 , 1.000 ]

[Input5]
Name='PainSensory'
Range=[ 0.000 , 1.000 ]
MF1='Sensitive','SemiTrapezoidalInf',[ 0.000 , 0.100 , 0.300 ]
MF2='NotSensitive','SemiTrapezoidalSup',[ 0.100 , 0.300 , 1.000 ]

[Input6]
Name='SoundSensory'
Range=[ 0.000 , 1.000 ]
MF1='NotSensitive','SemiTrapezoidalInf',[ 0.000 , 0.600 , 0.800 ]
MF2='Sensitive','SemiTrapezoidalSup',[ 0.600 , 0.800 , 1.000 ]

[Input7]
Name='FineMotor'
Range=[ 0.000 , 1.000 ]
MF1='Coordinate','SemiTrapezoidalInf',[ 0.000 , 0.600 , 0.800 ]
MF2='UnCoordinate','SemiTrapezoidalSup',[ 0.600 , 0.800 , 1.000 ]

[Input8]
Name='GrossMotor'
Visualization of membership, see in Fig. 2. Hypothetical fuzzy system for autism screening test

![Graph of membership functions](image)

**Figure 2** Fuzzy logic for autism screening test workflow

3.2 Fuzzy Rule

FISPRO we use to generate the rules. It generates 256 combinations of rules. After we simplified, the number of rule decreased to 126 rules. Examples of rules:

1. IF (Intellectual = Gifted) AND (SocialInteraction = VarietyOfFriendships) AND (Communication = Verbal) AND (RepetitiveBehaviours = Mild) AND (PainSensory = Sensitive) AND (SoundSensory = Sensitive) AND (FineMotor = Uncoordinate) AND (GrossMotor = Coordinate) THEN NOT

2. IF (Intellectual = Gifted) AND (SocialInteraction = VarietyOfFriendships) AND (Communication = Verbal) AND (RepetitiveBehaviours = Mild) AND (PainSensory = NotSensitive) AND (SoundSensory = NotSensitive) AND (FineMotor = UnCoordinate) AND (GrossMotor = Coordinate) THEN NOT

3. IF (Intellectual = Gifted) AND (SocialInteraction = VarietyOfFriendships) AND (Communication = Verbal) AND (RepetitiveBehaviours = Mild) AND (PainSensory = NotSensitive) AND (SoundSensory = Sensitive) AND (FineMotor = Coordinate) AND (GrossMotor = Coordinate) THEN NOT

...
126. IF (Intellectual = Disability) AND (SocialInteraction = NotInterestToTheOthers) AND (Communication = NonVerbal) AND (RepetitiveBehaviours = Intense) AND (PainSensory = Sensitive) AND (SoundSensory = NotSensitive) AND (FineMotor = Coordinate) AND (GrossMotor = UnCoordinate) THEN NOT

The full rules [15] locate at https://osf.io/M6G3N/.

3.3 Defuzzification
At this stage of the defuzzification results using these parameters:
  - Nature='fuzzy'
  - Defuzzification='MeanMax'
  - Disjunction='max'
  - DefaultValue= -1.000
  - Range=[ 0.000, 1.000 ]
  - MF1='Not','SemiTrapezoidalInf'[-0.650, 0.650, 0.700 ]
  - MF2='Autism','SemiTrapezoidalSup'[ 0.650, 0.700, 1.300 ]

Examples from diagnostic test results are at table 2. Screening test result. Diagnosis issued by the system is equipped with the membership percentage.

| Intellectual | Social Interaction | Communication | Repetitive Behaviours | Pain Sensory | Sound Sensory | Fine Motor | Gross Motor | Diags         |
|--------------|--------------------|---------------|-----------------------|--------------|---------------|------------|-------------|---------------|
| 1            | 0.5                | 0.5           | 0.5                   | 0.5          | 0.5           | 0.5        | 0.5         | -1 (Not)      |
|              |                    |               |                       |              |               |            |             | 0.994 (Autism)|
| 2            | 0.5                | 0.5           | 0.5                   | 0.62         | 0.75          | 0.78       | 0.65        | 0.01 (Not)    |
|              |                    |               |                       |              |               |            |             | 0.99 (Autism) |
| 3            | 0.43               | 0.37          | 0.72                  | 0.5          | 0.75          | 0.72       | 0.57        | 0.325 (Not)   |
|              |                    |               |                       |              |               |            |             | 0.325 (Not)   |
| 4            | 0.43               | 0.37          | 0.82                  | 0.5          | 0.73          | 0.75       | 0.72        | 0.99 (Autism) |
|              |                    |               |                       |              |               |            |             | 0.99 (Autism) |
| 5            | 0.43               | 0.37          | 0.82                  | 0.5          | 0.37          | 0.48       | 0.67        | 0.57 (Not)    |

4. Conclusion
This system is assigned to diagnose autism based on the recognized symptoms, where the number of asked questions can vary according to needs but still refers to the symptoms. This system was a theoretical simulation and has not been clinically tested. The diagnostic gives you the option from nominal become fuzzy. The diagnosis using this system can give a better interpellation and precision.
5. Future Research

This research is still a prototype and the data used is still in the form of a simulation study. The ways to measuring the answer still could be developed, including using a fuzzy Linkers scale. Comparison for accuracy with the other methods also still can be done.

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