Designing a Screening Technique to Diagnose Autistic Children

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Abstract

The purpose of this paper is to design and develop an electronic device that will allow parents of an autistic child to diagnose the level of autism by identifying the risk factors of autism that their children may possess. The device can be used as an early screening technique to identify children who are at risk for autism. Early diagnosis can enhance an autistic child's social, emotional, intellectual and physical development and may provide an optimal foundation for independent living. The paper is proposing the design of a concept for an Electronic Engineering Technology (EET) digital circuit course that will enhance academic service learning for the EET students. Designing an electronic device to diagnose the risk level for autistic children will build a link between the community and the university. A service learning integrated EET course also benefits faculty as it enables more process-oriented teaching and engages all learners.

Background

Early detection can help an autistic child recover from autism:

Autism is a spectrum of disorders for which symptoms can appear in early childhood causing delays in many basic areas of development, such as learning to talk, play, and interact with others. No parent wants to accept the unwanted truth that his precious little child has autism. But early diagnosis and treatment of autism can help overcome the effects of the developmental disorder and help a child learn, grow, and thrive which could lead toward potential independent living.

In this paper we are designing a tool to diagnose the risk of autism among children. It is very similar to that of a blood pressure machine we get to see in most of the pharmacies that serves as a tool for customers to test their own pressure in order to verify their own risk level for a heart disease. Unlike those pressure testing machines, this device can be placed at any children's clinic where parents will have access to it while waiting to be called for their doctors' appointment.

There are different opinions among doctors, parents, and experts about what causes autism and how best to treat it, however, everyone agrees that early diagnosis and intensive intervention can help recovery. If a child's social and emotional development does not seem to be on course, parents can use this tool to diagnose the risk level involved to recognize if his or her child has autism.

Figure 1: Early Signs of Autism (National Autism Society):

A person with ASD might:

- Not respond to their name (the child may appear deaf)
- Not point at objects or things of interest, or demonstrate interest
- Not play "pretend" games
- Avoid eye contact
- Want to be alone
- Have difficulty understanding, or showing understanding, or other people's feelings or their own
- Have no speech or delayed speech
- Repeat words or phrases over and over (echolalia)
- Give unrelated answers to questions
- Get upset by minor changes
- Have obsessive interests
- Flap their hands, rock their body, or spin in circles
- Have unusual reactions (over or under-sensitivity) to the way things sound, smell, taste, look, or feel
- Have low to no social skills
- Avoid or resist physical contact
- Demonstrate little safety or danger awareness
- Reverse pronouns (e.g., says "you" instead of "I")
- Gives unrelated answers to questions

People with autism may also:

- Have unusual interests and behaviors
- Have extreme anxiety and phobias, as well as unusual phobias
- Line up toys or other objects
- Play with toys the same way every time
- Like parts of objects (e.g., wheels)
- Become upset by minor changes
- Have obsessive interests

Other Symptoms:

- Hyperactivity (very active)
- Impulsivity (acting without thinking)
- Short attention span
- Aggression
- Causing self-injury
- Meltdowns
- Unusual eating and sleeping habits
- Unusual mood or emotional reactions
- Lack of fear or more fear than expected
- Have unusual sleeping habits

Late diagnosis may cause an irreversible condition that will lead to confusion about oneself and difficulties in learning and relating to others. The American Academy of Pediatrics (AAP) recommends that all children receive autism screening at 18 and 24 months of age.

According to the National Autism Association, autism can occur in all ethnic, socioeconomic and age groups and range from very mild to very severe. Males are four times more likely to have autism than females. Some children with autism appear normal before age 1 or 2 and then suddenly "regress" and lose language or social skills they had previously gained. Yet, there are many early signs and symptoms they possess that can indicate this regressive type of autism.

Design Process

Categorizing the system inputs:

The early signs of autism vary widely, as do its effects. Some autistic children have only mild impairments, while others have more severe obstacles to overcome. However, every parent of a child on the autism spectrum should be on the lookout for the early signs of autism. Above mentioned signs and symptoms of the neurodevelopmental disorder can be characterized in four different fundamental categories (webMD):

- A = Abnormalities in initiating communication with others: Rather than asking for help with something, the child may struggle alone without looking around for assistance.
- B = Impaired ability to initiate and respond to opportunities to share experiences with others: Children with autism may not follow their parents gaze or initiate contact with others.
- C = Irregularities when playing with toys: Instead of using a toy as it is meant to be used, like picking up a toy fork and pretending to eat with it, the child may do something unusual with the toy.
- D = Significantly reduced variety of sounds, words, and gestures used to communicate: Compared with typically developing children, children with autism have a much smaller inventory of sounds, words, and gestures that they use to communicate with others.

For our digital circuit design, A, B, C, and D, are the system inputs; V, W, X, Y, and Z are the system outputs that will represent the risk level:

- V = None
- W =Mild
- X = Moderate
- Y = High
- Z = Very High

After identifying the outputs and the inputs the truth table was created, a typical procedure in digital circuit design. If there is no symptoms present in your child's behavior, then there is no cause of concern for the child to be autistic. The output V is 'true'.

If you can identify only one of the inputs, defined by the four input categories, is present then the child is identified as mildly at risk of having autism. There are five possible combination of inputs when this output W is 'true'.

If you can identify three of the inputs, defined by the four input categories, are present then the child is identified as moderately at risk of having autism. Consequently, output X is 'true'. There are four possible combination of such inputs.

If three of the four inputs are present then the child is identified as highly at risk of having autism. Consequently, output Y is 'true'. There are four possible combination of such inputs.

Finally, if all four of the inputs, defined by the four input categories, are present then the child is very likely at risk of having autism. Consequently, output Z is 'true'. There is only one possible combination of such input.

Figure2: Truth Table

INPUTS				OUTPUTS				
A	B	C	D	V	W	X	Y	Z
0	0	0	0	1➔A'B'C'D'				
0	0	0	1		1➔A'B'C'D			
0	0	1	0		1➔A'B'CD'			
0	0	1	1			1➔A'B'CD		
0	1	0	0		1➔A'BC'D'			
0	1	0	1			1➔A'BC'D		
0	1	1	0			1➔A'BCD'		
0	1	1	1				1➔A'BCD	
1	0	0	0		1➔AB'C'D'			
1	0	0	1			1➔AB'C'D		
1	0	1	0			1➔AB'CD'		
1	0	1	1				1➔AB'CD	
1	1	0	0			1➔ABC'D'		
1	1	0	1				1➔ABC'D	
1	1	1	0				1➔ABCD'	
1	1	1	1					1➔ABCD

Boolean expression using Sum of Product Method (SOP):

V = A'B'C'D'

W = A'B'C'D + A'B'CD' + A'BC'D' + AB'C'D'

X = A'B'CD + A'BC'D + A'BCD' + AB'C'D + AB'CD' + ABC'D'

Y = A'BCD + AB'CD + ABC'D + ABCD'

Z = ABCD

Where logically, A' = NOT A, B' = NOT B, C' = NOT C, AND D' = NOT D

Minimizing the circuit (Karnough Maping):

Karnaugh Map for the output W, mildly at risk, is produced below and the Boolean expression for each of the output were derived and implemented into the digital circuit:

	C'D'	C'D	CD	CD'
A'B'		1		1
A'B	1			
AB				
AB'	1			

W = A'B'C'D + A'B'CD' + A'BC'D' +AB'C'D'

Karnaugh Map for the output X, moderately at risk, is produced below and the Boolean expression for the output is derived:

	C'D'	C'D	CD	CD'
A'B'			1	
A'B		1		1
AB	1			
AB'		1		1

X = A'B'CD + A'BC'D + A'BCD' + ABC'D' + AB'C'D + AB'CD'

Karnaugh Map for the output Y, highly at risk, is produced below and the Boolean expression for the output is derived:

	C'D'	C'D	CD	CD'
A'B'				
A'B			1	
AB		1		1
AB'			1	

Y = A'BCD + ABC'D + ABCD' + AB'CD

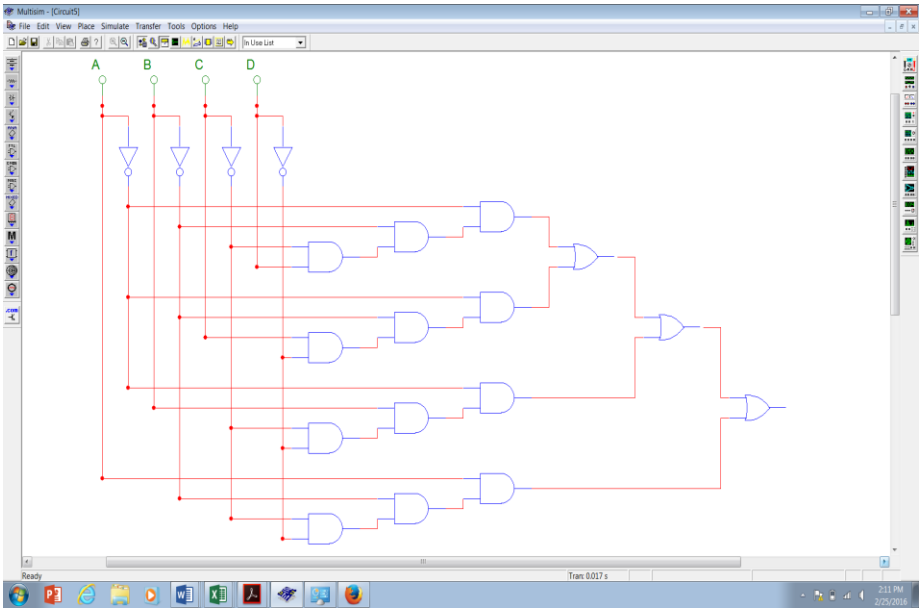
Karnaugh Map for the output Z, very highly at risk, is produced below and the Boolean expression for the output is derived:

	C'D'	C'D	CD	CD'
A'B'				
A'B				
AB			1	
AB'				

Z = ABCD

A sample digital circuit for the implementation of Boolean expression developed for the output W is shown in the following figure:

Figure 3: The digital circuit developed for ‘mildly at risk’ output W



Conclusion

Later, the design process could be improved, when each of these inputs will be weighted according to the statistical data instead of treating each of the inputs (A, B, C, & D) equally (25% risk factor). Such approach to service learning for risk measurement of autism will make many parents aware of autism, who otherwise could have remained ignorant about autism until it was too late. For some, early detection may be the difference between complete recovery from autism and living a normal life, or receiving lifelong assistance and dependent living.

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