Fuzzy Logic-based Visual Impairment Level Identification System for Pre-schoolers and Toddlers

MHK Sammani[1#], DU Vidanagama[1] and MPL Perera[2]
[1]Faculty of Computing, General Sir John Kotelawala Defence University, Ratmalana, Sri Lanka
[2] School of Electronic and Information Engineering, Hebei University of Technology, China
#37-is-0007@kdu.ac.lk

Abstract*— *Nearsightedness, or myopia, and Colorblindness, the two common eye diseases, can affect preschoolers and toddlers. This research is to provide parents with a method for testing the two eye impairments listed above in children who are illiterate in both letters and numbers. Using the knowledge offered by ophthalmologists, comments from parents with young children of survey findings, and pertinent literature, this is to create a mobile gaming application based on Fuzzy Logic that could evaluate the level of children's Colorblindness and Nearsightedness. The "Ishihara test" and "Hue test," which are still widely used today, can be used to identify color blindness by selecting hues from a color palette that have a similar color intensity, and by allowing children to choose images that range in size from large to small (follow the Snellen Chart), and Preferential Looking Test concept that parents can determine whether their child has nearsightedness based on the child's outward behavior. This mobile gaming application roughly identifies the level of the above two eye defects in young children and refers to medical advice if there is a certain risk level.

***Keywords*— Fuzzy Logic, Colorblindness, Nearsightedness, Mobile gaming application**

I. INTRODUCTION

Children under the age of five frequently experience visual impairments such as nearsightedness (myopia), and color blindness. It is thought that visual abnormalities can be quickly controlled if they are identified and corrected at a young age. This research study intends to provide an idea for a technique for using artificial intelligence technology to discover eye problems. As a result of the extremely low prevalence of certain eye abnormalities in young children, farsightedness is not taken into account in this study. The condition is prevalent in those over 40.

A. Research Background

1) Color Blindness:

Many children as young as 18 months begin to comprehend the principles of color. Around the ages of 2 and 3, they may begin to name colors. After roughly age 4 years, a child with color blindness could have problems distinguishing between reds, greens, browns, and oranges. Children choosing incorrect colors could struggle to match the hues in their belongings or clothing.

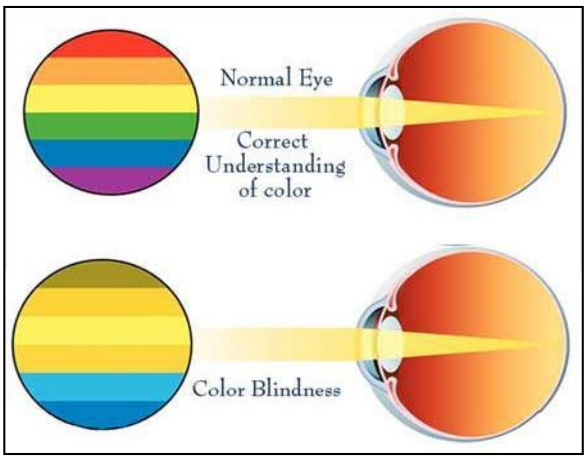

Figure 1. Difference between Normal Eye and Color Blindness Eye

What are the common tests that might be understood that the child has color blindness? - Ishihara tests, Hue tests, Anomaloscope test: Children will be tested by turning a knob to set the lights at the same level in each eye-viewer's eyepiece.

2) Nearsightedness or Myopia:

The typical onset age for this eyesight issue is between the ages of 6 and 14. Around 5% of toddlers, 9% of school-age children, and 30% of teenagers are impacted by it. A myopic baby could possibly develop emmetropia between the ages of 9 months and 4 years.

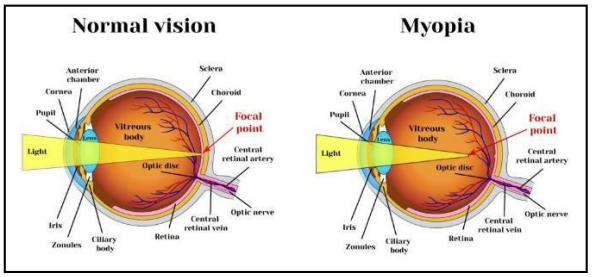

Figure 2. Difference between Normal Eye and Myopia Eye

Among the signs or symptoms of nearsightedness are blurry vision when gazing at distant objects, the need to squint or partially close one's eyelids in order to see clearly, headaches, and eyestrain. Children may also exhibit the following traits that point to vision problems: a tendency to squint constantly, an inability to focus on faraway objects, an excessive tendency to blink, a propensity to rub their eyes, and a tendency to watch television up close.

Common test for Myopia - The child must attend an optometrist or ophthalmologist to receive a diagnosis of myopia. The optometrist conducts an eye examination. The toddler will be asked to read letters on a chart or look at a light while having various lenses placed in front of their eyes. Special eyedrops may be administered to the youngster to assess the health of their eyes so that the optometrist can more clearly see the rear of the eye.

B. Research Problem Identification, Aim and Objectives

Nearsightedness or Myopia and Color blindness are two of the most common eye disorders in children today. But the toddlers and pre scholars do not have enough understanding to express their visual impairments, and even though the parents recognize that the child has some visual impairment through their child's external behavior, and the child is still unable to recognize and express letters, the children cannot face the eye tests appropriately. There are cases where parents have to wait until the child is older for eye examinations due to the lack of understanding to face it.

The goal is to develop a mobile gaming application which suitable for children mindset and that for parents to diagnose toddlers' and preschoolers' vision problems at home using artificial intelligence technology, based on the wishes of ophthalmologists and parents of young children.

Through the use of this research, a simple Android game will eventually be developed to help young children at home diagnose vision problems like color blindness and nearsightedness. In order to do that, this research will examine research papers on color blindness and nearsightedness, choose the most appropriate ones for a future use, go over them, and highlight the key elements. And to meet ophthalmologists and talk about how to use AI to develop a straightforward Android game that can detect the above eye disorders. Several parents of young children were chosen, and their opinions about this were solicited via a questionnaire. The goal of reviewing research papers is to give the best solution for the abovementioned research problem based on the views of parents and ophthalmologists.

Consider the above-mentioned objectives, while conducting this research to cover the following research questions; what are the existing reviews conducted to identify the Color blindness and Nearsightedness for toddlers or preschoolers through AI?, as well as how is the suitability of utilizing AI, to detect the above 2 eye defects of young children?, and what are the techniques that can be taken from the past researches for identifying those eye disorders for children through AI?, finally, which is the best solution to identify those eye disorders through AI?

II. LITRETURE REVIEW

This litreture review makes an analysis of the methods that can identify Color Blindness and Nearsightedness by using diffrenet technologies led by Artificial Inteligence. In addition, this also explains which device is most suitable for parents to test tha above two eye defects of toddlers at home.

A. Identify Color Blindness

According to *Shahira K.C.* and *Lijiya A*, text-to-speech software solutions allow the blind to access documents thanks to technical improvements. They examine the body of research on comprehending graphs and obtaining visual encoding from them in this work. In order to enable researchers in human computer interaction to attain machine perception of visual data on a human level, this study examines current efforts in the extraction of chart data. In this era of visual data summarization, AI techniques can automate the underlying data extraction and generate natural language descriptions to assist users who are blind or visually impaired. Reviewing this study, one can gain an understanding of HCI (Human Computer Interaction) and how research is combined to identify children who are color blind. [11]

Dey S., *Roy S.*, and *Roy K.* claim to offer a fully automated system that interacts with the patient and doesn't require outside assistance. According to the study described, the Waggoner model, a color blindness test that is now in use, is made for preschoolers and uses shapes rather than numbers. Therefore, there is evidence that children are colorblind if they are unable to recognize shapes. Which is based on the assumption that a colorblind person won't be able to distinguish between colors that are equivalent. They gave digital eight some thought. It has seven lines, and depending on whether one or more of those lines are missing, it is translated into a variety of digits. The backgrounds of these lines as well as the lines themselves were meticulously crafted. The different buttons are also made with a colorblind person's potential perception of numbers and shapes in mind. To account for every conceivable type of colorblindness, they have taken considerable care. It has been transformed into a complete program for simple installation and use on the Windows platform. That method can be added to this research as needed. [3]

In their study, *Moudgil T, Arora R*, and *Kaur K.* indicated that they used the Ishihara's Type Test to diagnose color vision deficiencies. The test was conducted in a well- lit space that simulated daytime sunlight. Students were instructed to read the numbers on the test plates, and their responses were recorded. Less than 5 seconds were allotted for telling the number on a plate. The type of color blindness and the normality or deficiency of color vision are assessed based on the reading of the plate. To determine the prevalence of color blindness, gender distribution, and different types of color blindness, the data was compiled and examined. It will be done using SPSS version 20 and Microsoft Excel to assemble the data and perform the necessary statistical analysis. The chi square test was used to determine the p-value. This study might also incorporate that technique if a color blindness test was required. [9]

Fliotsos MJ, Zhao J, Pradeep T, Ighani M, Eghrari AO. (2020), the goal of the study was to contrast the Ishihara pseudoisochromatic color vision test with a color vision test available through a smartphone app (EyeHandBook). The

study concluded that the two tests were not equivalent and recommended using the same modality consistently in clinical situations requiring recurrent testing of color vision. The study also suggested that to accurately simulate color vision loss, digital color editing methods need to be improved. A color vision test modeled after conventional Ishihara pseudoisochromatic color vision plates is one of many screening tests available in the Eye Handbook app. In tests of color vision, differences between the physical and digital Ishihara replications were found. Because the two devices' screens, light levels, and image scale differ, the study's conclusions could have been biased. The ability of these image processing methods to accurately imitate patients with and without color vision problems must be determined. In order to design the color blindness test application for this study, the device's size and image color quality must be taken into account. According to this study, the Ishihara test concept is best for determining color blindness. Therefore, the "Ishihara Test" concept will be employed in the project.[4]

Lee, Jinmi & Dos Santos, Wellington. (2010), Three computational methods designed to help people who are colorblind are presented in this research. The initial instrument assesses color blindness and rates how severe it is. Based on fuzzy logic, the second tool enhances the visual quality of digital images. The final tool imitates color blindness to red and green. The study also created the DaltonTest, a diagnostic tool that classifies color blindness, illustrates its severity, and explores its different presentational forms. The DaltonTest result is used by the rectification tool to generate a fuzzy character for the application. The DaltonCor correction tool employs digital image processing to enhance colorblind people's visual capabilities. The study used 10 bitmap-32-bit images and several correction versions, including RGB, LMS, and with and without histogram equalization, to examine the effects of the correction tool.[7]

B. Identify Nearsightedness

The authors, *Lavric A., Popa V., Takahashi H.,* and *Yousefi S.,* report that they used a variety of machine learning algorithms to identify keratoconus and then tested the algorithms using real-world medical data, such as corneal topography, elevation, and pachymetry parameters gathered from OCT-based topography instruments from several corneal clinics in Japan. The suggested model might help doctors identify keratoconus earlier on in the disease's course when it is still preclinical, which is difficult to do with subjective evaluations. For corneal assessment and early-stage keratoconus detection, the method can be applied to stand-alone software or integrated into corneal imaging devices. Adding that method to this research is challenging because it concerns a straightforward android development, yet it can provide some useful insights. [5]

According to *Yang Y., Li R.,* and others, describe a deep learning system (DLS) that can identify myopia using pictures of the ocular surface. This DLS demonstrated great diagnosis accuracy and was able to learn the ocular appearance characteristics of myopia using a dataset collected from the Myopia AI Program. Therefore, it might be applied to routine myopia evaluation. This review could aid in identifying nearsightedness and in properly analyzing the survey results for this study. [13]

C. Suitability of testing these Eye Defects using mobile phone

This review, conducted by *Senjam S.S, Manna S.* and *Bascaran C.* (2021) aims to highlight accessible functions, uses, and benefits, such as those for education and the use of smartphones as assistive technology for the blind and visually impaired. It also discusses user advantages and challenges as well as usability testing conducted by app developers. Innovative assistive gadgets have been created as a result of advancements in "human-computer- interaction" research, with novel interface designs that make them more accessible and user-friendly for those with visual impairment. Touch displays offer completely hands-free human-smartphone interaction by moving the need for visual function to alternative bodily senses through haptic or sonic gestures. A person with vision impairment can interact with the contents of a smartphone by using a range of accessibility features. Youngsters are more familiar with smart phones today because of their complexity and inclination for utilizing them for the majority of chores. As a result, mobile applications are more suited for screening youngsters for color blindness and myopia.[10]

This literature review implies that although there are separate specialized methods for color blind testing currently in use, besides the traditional snellen chart method to test nearsightedness, there are scientific methods that are limited and difficult to use in general and simple as above. Therefore, the technologies that can be used to solve the problem presented above have been presented in detail through this literature review.

Accordingly, the Fuzzy Logic concept of Artificial Intelligence technology, Image processing and HCI techniques, as well as machine learning models can be used to test these 2 eye defects. Also, this implies that the mobile phone is the most suitable device for this test.

III. METHODOLOGY

By discussing the identified research problem with the supervisor, it was determined that it was appropriate to continue the investigation on the issue and that all necessary instructions had been received. Using Google Scholar, IEEE, and ResearchGate, thirty standard research papers relevant to the stated research subject were chosen, their abstracts were reviewed and the aspects pertinent to the study were highlighted.

The research's scope was decided upon after discussing it with an ophthalmologist and learning that young children typically do not have farsightedness. This was done using the ophthalmologist’s comments, supervisors' suggestions

and the information learned through reading research publications.

After determining the scope, select the five most appropriate research papers from the 30 selected research papers and study the techniques discussed in them. Discussed the concerns there with the supervisor and eye professional in order to find solutions. A sample of 30 parents with young children were selected and their opinions on this were known through a survey.

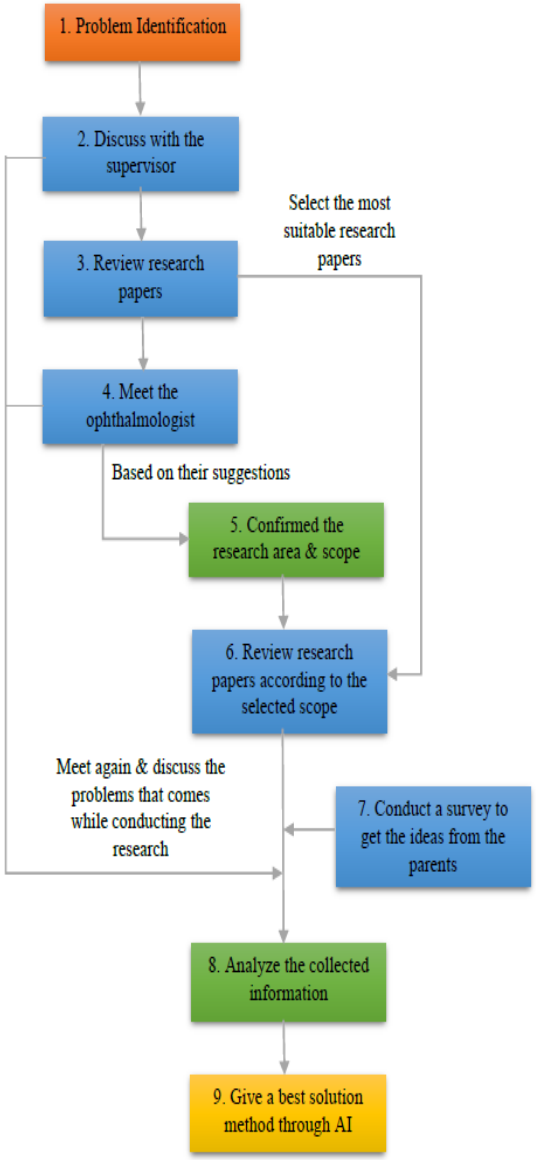

Figure 3. Diagram of research flow

Source: Author

IV. Analysis

A. *Ophthalmologist's suggestions;*

Suggest to the most appropriate method is developing a mobile gaming application suitable for childrens' usage, under the guidance of the parent. For Colorblindness:- Suggest following the "Ishihara Test" concept; to instruct child to drag the finger around the viewable Ishihara test image. And suggest to follow the "Hue Test" concept to arrage the different shades of colors into the most closet color order.

For Nearsigtedness:- Suggest to follow the "Snellen Chart" concept and "Preferential looking test" concept which are suitable for children's mindset. And parents must consider the child's external behaviors. Ex: should consider the child's arm and eye actions.

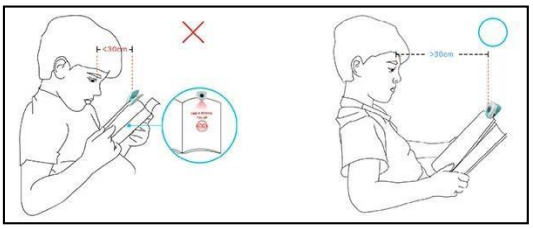

Figure 4. Difference between Myopia Child and a Normal Child when Reading a Book.

Suggest instructing the parents to consider the hand/ arm behaviors in the child. As an example; keep the phone 30 cm away from the eye of the child and keep the phone in an arm angle of 60^0 from the child's eye. So, if the child gets the phone closer to the eye that child has some Myopia symptoms.

B. *Supervisor's suggestions;*

It is best to develop a "Fuzzy Logic" for both Color blindness and nearsightedness for this game. Because the level of visual impairment can get using the scoring system by following the Fuzzy Logic concept.

C. *Past Research papers;*

For Colorblindness:- Enable to use of HCI, to attain machine perception of visual data on a human level and can follow the Waggoner model. It would be based on Ishihara Test and Hue Test concepts. Must consider the devices' screens, light levels, and image scales differ, the study's conclusions could have been biased. Can use Image processing techniques, Can follow DaltonTest concept.

For Nearsightedness:- Mostly using Machine learning algorithms. Example: Multi-layer perception models. Can follow Deep Learning Systems.

D. *Survey results from parents;*

More than 65% of parents are willing to develop a mobile gaming app for the abovementioned problem. More than 55% of the parents from the sample are liked to detect and check their child's eyes at an early age and at home.

31.1% of the parents have checked the eyes of their children and 68.8% are not checked yet. The reason for that cannot identify the problems of a child's external behaviors, are unable to identify the letters and numbers properly, etc.

And also 21.9% of the parents from the sample, they are not like to create a mobile gaming app, because some of them mentioned must monitor what kids are doing with the mobile, and some mentioned children do have not enough knowledge about how to use the mobile phone.

Therefore, Will developing this game, While the child is playing the game, it is advisable to determine the defect by providing answers to the questions directed to the parents by the system according to the way the child plays the game.

V. Results and Discussion

The findings and results of this research can be summarized as follows in perspective of the aim of the research and the analysis performed on the data gathered from outside sources.

A. Findings

This solution is a way to detect Nearsightedness and Color blindness in children under five years of age. The most appropriate method is to identify whether or not the child has visual defects by playing the game under the guidance of the parents.

Pictures and colors are more suitable because this game was made for kids who have trouble reading letters and numbers.

To test Colorblindness; one must consider the most popular testing methods such as the Ishihara test and Hue test concepts and to test Nearsightedness; one must consider the most preferred myopia testing methods such as Snellen Chart and Preferential Looking Test concepts which are suitable for children's mindset.

B. Results

About 85% of the findings from the analysis are the same as the aim of the research. In 75% of the research publications on color blindness, approaches for identifying the condition are based on HCI, while in 80% of the studies on nearsightedness, methods are based on machine learning models.

Additionally, a 95% percentage suggests that it is more acceptable to identify these two vision impairments in young children using a Fuzzy Logic Concept in AI, in the view of the ophthalmologist and the supervisor and also parents.

Therefore, using HCI and machine learning techniques, using artificial intelligence technology, and developing a straightforward Android game as a fuzzy logic-based system to identify the level of nearsightedness and color blindness, which is more appealing to young children, is the best solution in relation to the aforementioned research problem. That is inferred from the research's previously indicated aspects.

The above data are presented quantitatively below.

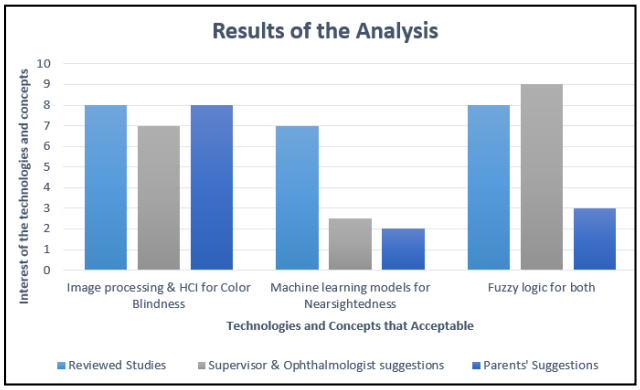

Figure 5. Results of the analyzed data of the research

Source: Author

VI. Research Work

The process of the project is as below;

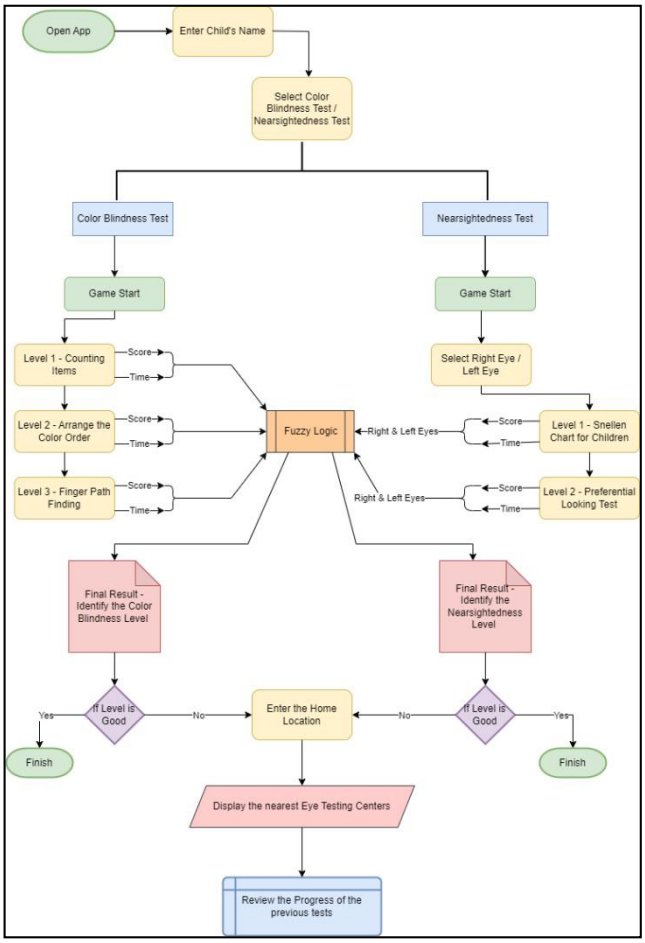

Figure 6. Project Process Diagram

Source: Author

The colorblindness test and Nearsightedness test have separate levels and each level provides a score. That scoring system developing on MATLAB. MATLAB rule base structure is as follows;

Input 1: Correctness of a level (High, Medium, and Low).

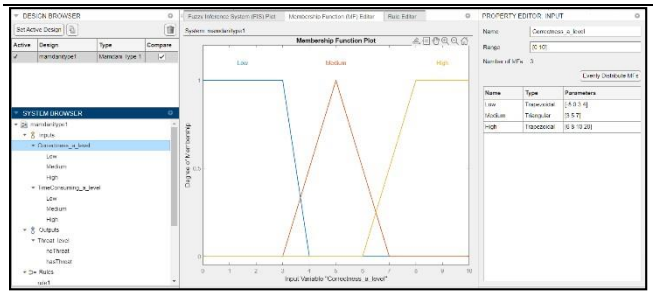

Figure 7. Membership Function Plot – Input variable: Correctness_a_Level

Source: MATLAB

Input 2: Time-consuming of a level (High, Medium, Low).

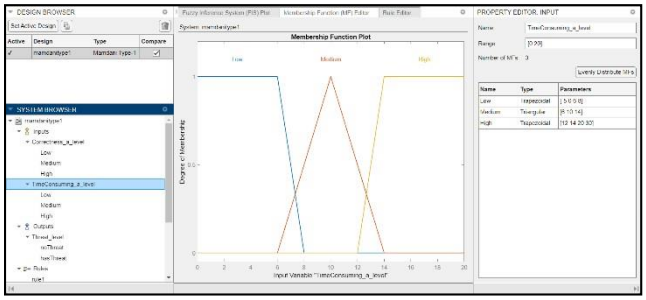

Figure 8. Membership Function Plot – Input variable: TimeConsuming_a_Level

Source: MATLAB

Output: Threat_Level (hasThreat, noThreat).

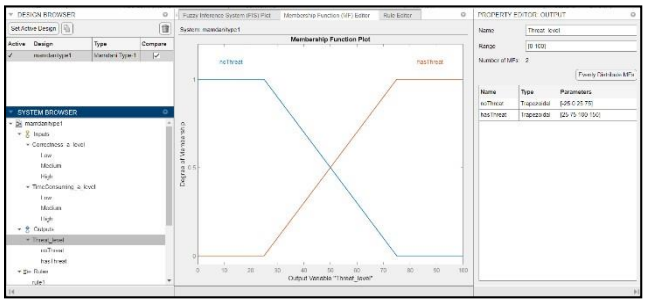

Figure 10. Membership Function Plot – Out variable: Threat_Level

Source: MATLAB The fuzzy Logic rule

base is as follows;

Rule 1: If Correctness_a_level is Low and TimeConsuming_a_level is Low then Threat_level is hasThreat
Rule 2: If Correctness_a_level is Medium and TimeConsuming_a_level is Low then Threat_level is hasThreat
Rule 3: If Correctness_a_level is High and TimeConsuming_a_level is Low then Threat_level is noThreat
Rule 4: If Correctness_a_level is Low and TimeConsuming_a_level is Medium then Threat_level is noThreat
Rule 5: If Correctness_a_level is Medium and TimeConsuming_a_level is Medium then Threat_level is hasThreat
Rule 6: If Correctness_a_level is High and TimeConsuming_a_level is Medium then Threat_level is noThreat
Rule 7: If Correctness_a_level is Low and TimeConsuming_a_level is High then Threat_level is hasThreat
Rule 8: If Correctness_a_level is Medium and TimeConsuming_a_level is High then Threat_level is hasThreat
Rule 9: If Correctness_a_level is High and TimeConsuming_a_level is High then Threat_level is hasThreat

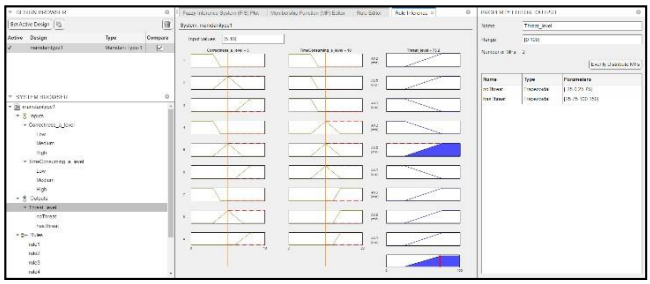

Figure 9. Rule

Inference

Source: MATLAB

Ps: In above mentioned all the values are rough values that
are only used to test the structure of the Fuzzy Logic rule base creation.

VII. PLAN OF EVALUATING THIS MODEL

During the development process, planning to test this app using at least 10 children where give them to play those games. And identify the difficulties they faced playing those games. Then can develop this app to the most appropriate way and it would be more comfortable for children. These testing processes will do several stages of the development process also. After planning to deploy these models to test with the ophthalmologists and Eye specialists, user expectations change something's need to their perspectives. Then finally, hope to develop a most straightforward model with the mobile gaming app that is most usable for pre-schoolers and toddlers to identify the level of their color blindness and nearsightedness under their parents' guidance.

VIII. CONCLUSION

By utilizing Nearsightedness and Color blindness as two visual impairments in children under the age of 5, this research based on Artificial Intelligence will address issues that have developed in the detection of these conditions using Human-Computer Interaction (HCI) and AI techniques called Fuzzy Logic. It is the best option for building a straightforward and appealing Android app.

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