Expert System for Diagnosis of Cataracts in Children With Bayes Theorem

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Expert System for Diagnosis of Cataracts in Children With Bayes Theorem

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Abstract - The branch of Artificial Intelligence science is an expert system that is a combination of expert experience and an inference engine to produce knowledge. With an expert system, a user will get the knowledge that comes from the system, just like meeting an expert. Many cases can be resolved by an expert system, including: in the medical, agricultural, and other fields. In this study, the expert system applies the Bayes method, which is a method that uses probability to determine whether a user is suffering from illness. The case that will be resolved by the expert system is the early detection of cataracts affecting infants and minors. Cataracts in children are generally caused by premature birth, the mother suffers from rubella during pregnancy, the consumption of food during pregnancy. Types of cataracts suffered by infants and children such as Congenital, Juvenile, Traumatic cataracts. The results of this expert system show that children has congenital cataracts by 50% based on the selected symptoms, namely G001, G002, G004, and G012 of a user based on the probability value that a user has.

Keywords-theorema bayes, expert systems, children, artificial intelligence

I. INTRODUCTION

The eye is the most important organ in life, in order to see an object clearly the eyes must have good vision. The eye abnormalities or damage because of some symptoms sometimes without realizing it can damage and interfere with our own vision.

A Cataract is a disease when the lens of the eye becomes cloudy and cloudy. In general, cataracts develop slowly and do not feel bothersome at first. However, over time, cataracts will interfere with vision and make sufferers feel like they are seeing a foggy window, have difficulty driving, reading, and doing daily activities. This disease is the leading cause of blindness in the world that can be healed. A Cataract is a non-communicable disease did influenced by various factors, both internal and external factors[1]. Cataract is a major cause of avoidable blindness and visual impairment throughout the world and is likely to present an increasing burden to health care systems[2]. Cataracts on the child are one of the primary causes of visual impairment and blindness in children. According to IAPB data in 2018, blindness occurred in 1,025 million children worldwide [3] : Cataracts on the child are most often found in boys that less than two years. The majority of these cataracts are bilateral and the largest type is membranous. The most common cause was wooden stick 23 (28.0%) and sharp thorn 14 (17.1%)[4]. Current test Cataract detection from retinal is expensive using fundus camera as the detection is the key reason for this is not portable, needs an expert to perform the operation[5].

The commonly performed cataract surgery technique is a combination of aspiration - irrigation, primary posterior capsulotomy, and anterior vitrectomy[6]. Cataract surgery was planned after the primary sutures were removed, once a suitable period had passed for the in§ ammation to subside. All surgeries were performed by a single experienced surgeon (YO). Children younger than 2 years routinely underwent LA with posterior capsulotomy (PC) and anterior vitrectomy (AV), and a secondary intraocular lens (IOL) implantation was performed after 2 years of age[7]. Cataract removal surgery was conducted in 16 (89%) with intraocular lens (IOL) implantation in 14 (87.5%), while 2 remained aphakic (12.5%). Two (11%) were treated conservatively. Long-term complications included IOL dislocation in 5 (36%), glaucoma in 8 (44%), and posterior capsular opacity in 10 (71%). No correlation was found between final visual acuity and the time interval between injury and IOL implantation nor between final VA and age at trauma. However, the final VA did correlate with time of follow-up[8].

There are several types of cataracts based on causes as if congenital cataracts, which are cataracts that appear at an early age (infants under one year), Juvenile cataracts are an increase in congenital cataracts seen over one year of age and reaching under fifty years of age and traumatic cataracts [9]. Radiation is the main cause of cataract development, more than 45 children received CSI and underwent ophthalmological examinations whom 13 of them had cataracts. Meanwhile, the average time that cataract occurs is about 27.6 months, of which seven children underwent cataract surgery. Given the high incidence of cataracts, we recommend routine eye examinations for all children receiving CSI [10].

Early diagnosis of child health problems helps professionals to treat them early and improve their quality of life, machine learning techniques such as Support

Vector Machines, Naive Bayes classifier, K-Nearest Neighbor, Decision Tree, K-means algorithm and perform a comparative analysis of their accuracy and help researchers to choose the best algorithm for predicting various children's health problems [11]. Radiation is a well-known cause of cataract development.

For children with brain tumors, craniospinal irradiation (CSI) is expected to result in a significant risk of cataract development[10]. A common treatment for pediatric cataracts is to replace the cloudy lens with an artificial lens. However, patients may develop complications (severe lens proliferation to the visual axis and abnormally high intraocular) [12].

Chronic hyperglycemia in patients with type 1 diabetes (T1D) results in eye problems over time, but only a few studies have focused on cataracts. The Health Insurance Database (LHID) is presented as a template for the general population. In the first section, a total of 3,622 T1D cases registered between 1998 and 2007 were enrolled and compared with the matched cohort of LHID. To identify risk factors for cataracts in the T1D population in the second section, a total of 9032 T1D cases registered between 1998 and 2013 were included. Results. Compared with LHID, the cataract hazard ratio (HR) in the T1D group was 5.81 (95% CI 4.60–7.33), and HR was higher in women (6.29, 95% CI 4.63–8, 55). The peak incidence of cataracts occurred between the ages of 20 and 29 years in the T1D group (Lu et al., 2020). To evaluate the factors influencing final visual acuity in pediatric traumatic cataracts. Data on patients with traumatic cataracts were reviewed retrospectively in terms of gender, age at trauma; trauma type, cause, and zone. Overall, 61 eyes of 59 patients with cataracts after trauma, were under 16 years of age. The mean age of the children was 7.2 ± 3.9 years [7].

Ocular trauma in the pediatric population can lead to cataract formation. Visually immature children are a major challenge and can result in poor visual outcomes. To review our long-term surgical experience with childhood unilateral traumatic cataracts. Of the 18 children included in the study, 83% were men. The mean follow-up time was 12.5 years. The median age at injury was 7.5 years. Eleven patients (61%) presented with penetrating traumatic injury and 7 (39%) with blunt trauma. Sixteen patients (89%) had cataracts at presentation, whereas two cataracts developed during follow-up. Of the 18 total, cataract removal. Surgery was performed in 16 (89%) with intraocular lens (IOL) implantation in 14 (87.5%), while 2 remained aphakia (12.5%). Two (11%) were treated conservatively. Long-term complications included IOL dislocation in 5 (36%), glaucoma in 7 (39%), and posterior capsule opacity in 10 (71%). No correlation was found between final visual acuity and time interval between injury and IOL implantation or between late VA and age at trauma. However, late VA does correlate with follow-up time [8], Many researchers conducted studies using multiple algorithms. Of the identified variables, the Decision Tree C4.5 algorithm revealed that smoking, myopia intensity, lens use, and frequency of alcohol consumption were the most relevant risk factors of cataract risk in the 26 identified variables. The results also show that of all the supervised machine learning algorithms used, Perceptron Multi-layer was able to predict all records (100% accuracy) of the historical dataset used whereas Decision Tree Classifier C4.5 and Naïve Bayes had an accuracy of 87% and 84, respectively. %(Balogun et al., 2017). System applications can be built using the Case-Based Reasoning (CBR) method. The diagnostic process using the CBR method is carried out by calculating the similarity of values between old cases and new cases. Old cases are a number of records that have occurred in the past and have been proven to be true [13].

Indonesia is the country with the second highest blindness rate in the world after Ethiopia with a prevalence of over 1%. The high rate of blindness in Indonesia is not only a health problem but also become a social problem. Based on data from the World Health Organization (WHO) (2012), cataracts are cause most of the blindness in the world. There are 39 million people who are blind worldwide. Besides, cataracts are the second cause of visual impairment in the world with an incidence of 33% (Ministry of Health, Republic of Indonesia, 2014) [14].

As for the symptoms of cataracts that suffered by children like the two eyes that are not aligned, the pupils are white when examined with a flashlight, reduced vision and blurred or blurred vision, patterned and involuntary eye movements, eyes moving in the direction of not necessarily as the eye looks up and down. In this case, we focus in discuss Congenital, Juvenile, and Traumatic cataracts. This expert system application is used to allow users to diagnose symptoms of the disease before taking further action.

II. METHODOLOGY

A. *Expert System*

An expert system is a computer program designed to have the ability to solve problems like an expert. A good expert system is designed to solve certain problems by imitating the abilities of experts in their respective fields. Expert systems sometimes have better capabilities than an expert, so that system can be concluded, where the expertise transferred from an expert to a computer, existing knowledge is then stored in computer memory and the user can consult a computer for a specific purpose which is the computer .

An expert system is a collection of abilities that is transferred to a computer in the form of knowledge that is stored on the system to find solutions base on facts that we have been obtained[13]. The main objective of an expert system is not to replace the expert but as an intermediary between an expert and a user who requires knowledge in the field of expertise. On the other hand, an expert system can be an expert assistant who can help the performance of an expert ([15][16]

1. Expert System Structure

The expert system structure has two important parts, its call by development environment and a consulting environment. The development environment is used to feed the knowledge gained from the expert into the expert system and the consultation environment is used by users

to carry out consultations and to gain knowledge from experts [17]. The following is the structure of the expert system :

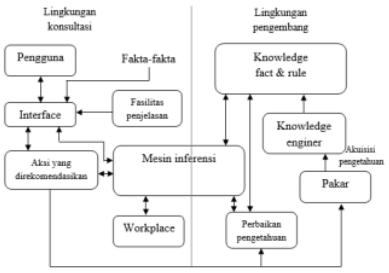

Fig 1. Expert System Structure

B. Bayes Theorem

1. Definition of Bayes Theorem

According to the journal [18], Bayes' theorem is a method used to calculate data uncertainty into certainty data by comparing true or false data. Ramadhan, 2019) Bayes' theorem is a rule that uses probability to produce the right decisions and information.

2. Bayes Theorem Formula

Bayesian probability is the one way to overcome data uncertainty, formula for handling representations of handling uncertainty is described below [20]:

1. To overcome single evidence E and single hypothesis H, it is defined as follows :

$$P(H|E) = \frac{p(E|H)\,xp(H)}{p(E)} \text{.....(1)}$$

Where :

p(H|E) : Probability that hypothesis H occurs if evidence E occurs.

p(E|H) : Probability of appearing evidence E, if hypothesis H occursi.

p(H) : Probability of Hypothesis H regardless of any evidence.

p(E) : Probability of Evidence E regardless of anything.

2. To overcome the single evidence E and the multiple hypotheses H1, H2, H3 … Hn, denoted as follows :

$$P(Hi|E) = \frac{(E|Hi)x(P(Hi))}{\sum_{ki}^{n} P(E|Hk)x(P(Hk))} \text{.....(2)}$$

Where :

P(Hi|E) : hypothetical probability H if given evidence E

P(Hi|Hi) : probability of emergence of evidence E if known hypothesis H hypothesis

P(Hi) : probability of hypothesis H regardless of any evidence.

n : possible number of hypothesis.

3. To overcome the double evidence E1, E2,… En and the double hypothesis H1, H2, H3,…. Hn, denoted as follows :

$$p(Hi|E1E2 \ldots .En) = \frac{p(E1|Hi)xp(E2|Hi)x \ldots xp(Em|Hi)xp(Hi)}{\sum_{k=1}^{n} p(E1|Hk)xp(E2|Hk)x \ldots xp(Em|Hk)xp(Hk)} \text{.....(3)}$$

To find out the above equation, it is necessary to know the conditional probabilities, from all possible combinations of evidence for all hypotheses :

$$p(Hi|E1E2 \ldots Em) = \frac{p(E1|Hi)xp(E2|Hi)x \ldots xp(Em|Hi)xp(Hi)}{\sum_{k=1}^{n} p(E1|Hk)xp(E2|Hk)x \ldots xp(Em|Hk)xp(Hk)} \text{.....(4)}$$

The main components of the Expert System are:

C. *Knowledge Based*

The knowledge base is the main part of an expert system in the form of a description of the knowledge of an expert in a certain field which is then present in the form of a programming language, where the knowledge base consists of existing facts.

TABLE I. TYPES OF CATARACTS IN CHILDREN

DISEASE CODE	NAME OF DISEASE
P001	Kongenital
P002	Juvenil
P003	Traumatik

TABLE 2. CATARACT SYMPTOMS DATA

Symptoms Code	Name Of Symptoms	Type Of Disease
G001	Heredity or Genetics	*Kongenital*
G002	Infections during pregnancy (rubella, herpes simplex virus, cytomegalovirus, smallpox, and toxoplasmosis	
G003	Drug reaction	
G004	Eye trauma	
G005	Diabetes	
G006	Toxocariasis (parasitic infection that infects the eye)	
G007	Galatosemia (enzyme deficiency)	
G008	Cloudy eyes	
G009	Unusual eye movements (Nytagmus)	
G010	Eyeballs wiggle or squint	
G011	Blurred vision	*Juvenil*
G012	Dazzled	
G013	Changes in color vision	
G014	Decreased visual acuity	
G015	Diplopia monocular (double vision in one eye)	
G016	Bruises in the eye area (blunt objects)	

G017	Perforation wound (sharp object)	*Traumatik*
G018	Ray radiation	
G019	Due to chemical	
G014	Decreased visual acuity	
G012	Dazzled	
G020	Contrast sensitivity	

TABLE 3. SOLUTION FOR CATARACTS

No		Solution Code	Solution
1.	Kongenital	S01	Cataract surgery as early as possible.
		S02	Replacing the child's lenses with artificial lenses, or dressing the child with contact lenses or glasses.
2	Juvenil	S03	Surgery is done if the patient can not see well with the help of glasses to perform daily activities.
		S04	Perform surgery if the patient complains of visual disturbances in carrying out routine work.
		S05	Consume vegetables such as spinach, carrots, and broccoli.
3.	Traumatik	S06	Blunt: A special examination is carried out, and requires serious treatment by a doctor.
		S07	Perforation / Sharps: Surgery is carried out as soon as possible so that there is no infection in the eye.
		S08	Rays and Chemicals: Performed a special examination by an ophthalmologist.

D. Rule Base

The rules that use in this expert system are described as follows:

R1 = **IF** Heredity or genetics [G001] **AND** Infection during pregnancy [G002] **AND** Drug reaction [G003] **AND** Eye trauma [G004] **THEN** disease = Congenital Cataract [P001]

R2 = **IF** Galatosemia [G007] **AND** Unusual eye movements [G009] **AND** Eyeballs wiggle or squint [G010] **AND** Toxocariasis [G006] **THEN** Disease = Congenital Cataract [P001]

R3 = **IF** Heredity or genetics [G001] **AND** Diabetes G005] **AND** Drug reaction [G003] **AND** Cloudy in the lens [G008] **THEN** Disease = Congenital Cataract [P001]

R4 = **IF** Blurred vision [G011] **AND** Dazzled [G012] **AND** Pcolor vision change [G013] **THEN** Disease = Juvenile Cataract [P002]

R5 =**IF** Decreased visual acuity [G014] **AND** Diplopia monocular [G015] **AND** Dazzled [G012] **THEN** Disease = Juvenile Cataract [P002]

R6 = **IF** Bruises in the eye area benda tumpul)[G016] **AND** Perforation wound (sharp object) [G017] **AND** Ray radiation [G018] **AND** Chemicals [G019] **THEN** Disease = Traumatic Cataract [P003]

R7 = **IF** Perforation wound (sharp object) [G017] **AND** Contrast sensitivity [G020] **AND** Decreased visual acuity [G014] **AND** Dazzled [G012] **THEN** disease = Traumatic Cataract [P003]

R8 = **IF** Ray radiation [G018] **AND** Bruises in the eye area [G016] **AND** Chemicals [G019] **AND** Dazzled [G012] **THEN** disease = Traumatic Cataract [P003]

E. Explanation Facilities

Explanation facilities are a medium for user discussion of the system. Explanation facilities will present a number of questions that will be answered by the user in accordance with the circumstances experienced by the user and at the end of the process, the explanation facilities will lead to certain conclusions.

next, we describe with an example of the explanation facilities that owned by this expert system:

TABLE 4. EXAMPLE OF EXPERT SYSTEM QUESTION

No	Question	Answer
1	Do you have a family history of having the same disease (cataract) (G001)	Yes
2	Have you ever had an infection during pregnancy (G002)	Yes
3	Does your child have a history of drug reactions [G003]	Yes
4	Has your child ever experienced trauma to the eye [G004]	Yes
5	Do you have diabetes [G005]	Yes
6	Does your child have Toxocariasis (parasite eye infection) [G006]	Yes
7	Does your child have Galatosemia (enzyme deficiency) [G007]	Yes
8	Do your child's eyes experience cloudiness in the lens [G008]	Yes
9	Does your child have Nygtamus (unusual eye movements) [G009]	Yes
10	Do your child's eyeballs wiggle or squint when opened [G010]	Yes
11	Does your child have blurred vision [G011]	NO
12	Does your child experience glare [G012]	NO
13	Does your child experience a change in vision when sees color [G013]	NO
14	Does your child have decreased visual acuity? [G014]	NO
15	Does your child have monocular diplopia (double vision in one eye) [G015]	NO
16	Has your child ever been bruised by a blunt object in the eye area? [G016]	NO

17	Has your child ever had a perforation wound or was hit by a sharp object in the eye area? [G017]	NO
18	Has your child ever been exposed to radiation? [G018]	NO
19	Has your child ever been exposed to chemicals in the eye area? [G019}	NO
20	Does your child experience contrast sensitivity when watching television or laptop? [G020]	NO

III. RESULT AND DISCUSSION

The symptoms formation matrix is to identify the possibility of the same symptoms appearing in different diseases. The purpose of this step is to determine the probability level of each disease.

TABLE 5. OF DISEASES AND SYMPTOMS

	P001	P002	P003
G001	1	0	0
G002	1	0	0
G003	1	0	0
G004	1	0	0
G005	1	0	0
G006	1	0	0
G007	1	0	0
G008	1	0	0
G009	1	0	0
G010	1	0	0
G011	0	1	0
G012	0	1	1
G013	0	1	0
G014	0	1	1
G015	0	1	0
G016	0	0	1
G017	0	0	1
G018	0	0	1
G019	0	0	1
G020	0	0	1

For example, if the user experiences the following symptoms, G001, G004, and G012, then the probability of Disease is P001, P002, and P003

Calculating Disease Probability P001 = (1/3 = 0.33)

Probability G001 = number of possible symptoms / number of possible diseases by symptoms = 1/ 3 =0, 33

Probability G004 = number of possible symptoms / number of possible diseases by symptoms = 1/ 3 = 0,33

Probability G012 = number of possible symptoms / number of possible diseases by symptoms = 0 / 3 = 0

Calculating Disease Probability P002 = (1/3 = 0.33)

Probability G001 = number of possible symptoms / number of possible diseases by symptoms = 0 / 3 =0

Probability G004 = number of possible symptoms / number of possible diseases by symptoms = 0 / 3 = 0

Probability G012 = number of possible symptoms / number of possible diseases by symptoms = 1 / 3= 0,33

Calculating Disease Probability P003 = (1/3 = 0.33)

Probability G001 = number of possible symptoms / number of possible diseases by symptoms = 0 / 3 = 0

Probability G004 = number of possible symptoms / number of possible diseases by symptoms = 0 / 3 = 0

Probability G012 = number of possible symptoms / number of possible diseases by symptoms = 1 / 3= 0,33

Probability P001 = Total Bayes P001 / Total All Bayes = (1 / 2) * 100 % = 50%

Probability P002 = Total Bayes P002 / Total All Bayes = (0,5 /2) * 100 % = 25 %

Probability P003= Total Bayes P003 / Total All Bayes = (0,5 /2) * 100 % = 25 %.

Based on the symptoms felt by the user, the possibility of the user suffering from P001 disease with the highest Bayes value of 50%. The user interface is a display that can be seen by visitors and users. The following is the user interface of the expert system for cataracts in children:

Fig 2: Consultation Form

After the user selects a symptom, the next step the system will perform Bayesian calculations based on the symptom selected by the user and present the prediction results in the form of a form as shown in Figure 2.

Fig 3: Prediction Result

IV. Conclusion

Based on testing of the expert system conducted by several users, this system can provide satisfactory prediction results on the possibility of cataracts being suffered based on the symptoms determined by the user. The confidence value strengthens the prediction results by providing a percentage value for the likelihood of disease. The percentage value can be used by a doctor in making quick conclusions about the cataract suffered by a user.

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