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Designing Fuzzy Expert System to Identify Child Intelligence

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Abstract

Every child is special and has her/his own unique potential. Identifying child's potential in early age is important for teaching purpose since every child has difference intelligence and interest. Therefore children's teaching and learning process should be delivered based on child's interest and intelligence, instead of forcing children to excel in every subject. We propose our research to identify child's intelligence by designing fuzzy expert system. The system works based on several input data of children's multiple intelligences. The fuzzy expert system is developed using 25 input variables and resulted in 9 output variables. The system classifies the result based on 9 types of intelligence in human, where each exhibits different level. We produce 81 rules with fuzzy set of three different levels value (high, moderate, or low) for every kind of intelligence. The result of this research is very useful to help parents and teachers for determining their method of teaching based on children's potential.

Keywords: *Fuzzy, Child intelligence, Expert system*

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1. Introduction

Identifying children's potential in early age is required to teach children based on their intelligence and interest, instead of forcing children to learn based on parents' and teachers' instructions. School curriculum tends to develop only two intelligences, which are logical-mathematical intelligence and linguistic/verbal intelligence. This fact causes children who are not good in those two aspects, categorized as stupid or less intelligent, while in reality they may have been more intelligent in other fields. The importance of teaching children according to their intelligence has been repeatedly stated by psychologist, however the problem lies in how every parent or children to identify which intelligence is in their children or students.

Many children are no longer interested in exact science such as Mathematics, Physics, and Chemistry. For these children, such subjects are harder to be understood, while these subjects are included in main curriculum or main competence which must be mastered by middle school to high school student. There are also many children do not realize which potential they possess even until they continue to higher education or looking for work. These children are still unable to find out their ability or intelligences. This happened because today basic formal education still not deeply explored children potential in early age. As a result, children in their adult age feel that they have chosen the wrong field in education or work.

Many children feel that their future will not be bright because their grade in sciences or mathematics is low. Such stigmas also spread around in society which causes parents to have more or less similar views. Thus, many parents are scared of the outcome and gives supplementary education for their children through private classes. In fact, such action may not be right and instead gives additional stress to children. Every child is unique and should be given different treatment depends on his or her capability and interests.

To resolve those problems, multiple intelligences in children can be detected by Fingerprint Test (FT). Several schools have implemented FT method to determine the right teaching method for children according to their respective intelligences. However, the testing fee is relatively expensive for middle to lower class citizen in Indonesia, being around 1-2 million rupiahs per child. Our literature studies also find that there are still not many researches can be found related to those problems. Researches on children intelligent are still focusing on child

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developmental disorder [1] and its design and simulation [2], whereas the fact in field show that identification of children intelligence with inexpensive fee is extremely needed. Authors in [3] develop expert system to identify children disorder under 10 years old, such as: mental retardation, autism, ADHD, and conduct disorder.

There are also several research conducted in children learning area. Authors in [4] create a tool to recognize mathematically gifted children using expert system, teachers, and psychologist estimation. Hernandez et al. [5] develop expert system to diagnose learning difficulties in children's basic education. Schipor et al [6] build a mobile application using knowledge base of expert system for dyslalic children therapy. The knowledge base have over 150 rules and 19 linguistic variables. Author in [7] develops e-learning model, in order to teach computer programming for secondary students. In order to solve the problem stated above, this research is performed. Our research has objective to design fuzzy expert system to identify children intelligence based on their interests and intelligence.

2. Research Method

We develop the system using expert system concept. Expert system is one of the areas of artificial intelligence, consists of knowledge and analytical skills to represent human experts in a specific problem domain [8]. In this research we create rule based expert system based on expert's judgment, known as knowledge acquisition. We interview 3 psychologists to transfer their knowledge to our expert system. The knowledge engineers then translate the knowledge gathered from human expert and build the knowledge base.

Author in [9] explains architecture of simple expert system, which contains of: Knowledge base, knowledge base acquisition facility, user interface, inference engine, and explanation facility. Figure 1 illustrates the architecture of simple expert system.

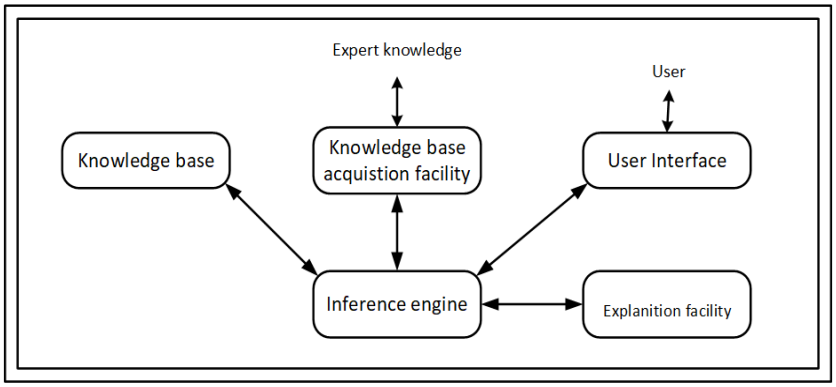

Figure 1. Architecture of simple expert system

As explained before, the knowledge acquisition process in this research is done through experts' interview. Sometimes, the expert's knowledge and judgment is "fuzzy", therefore the knowledge engineer should be able to express the knowledge and represent it into mechanisms, rules, and codes. Based on the concept of expert system's architecture above, we employ our research method in several stages, i.e.: (1) Problem identification, (2) Base knowledge searching, (3) Knowledge acquisition, (4) Knowledge representation, (5) Inference machine development, and (6) Implementation and testing. The explanation of each stage is as follows:

2.1. Problem Identification

The expert system development process begins with the identification of the problem areas studied as well as the specific tasks to be addressed. The expert system built aims to assist users in formulating facts and knowledge base to identify the intelligence of children so that children can be directed in accordance with their respective potential. The next stage is the determination of the type of input and output to identify the type of intelligence in children.

2.2. Base Knowledge Searching

The search for knowledge resources includes expert search activities, literature, and necessary data. The expert is someone who has expertise and knowledge in the field studied which in this case is about the intelligence of the child. The expert for this system comes from practitioners and psychology lecturers.

2.3. Knowledge Acquisition

Acquisition of knowledge is used as the transfer process and transformation of expertise to solve problems from several sources of knowledge to the program [1] [10]. This stage is an important stage and determines the success of expert systems to be built. Knowledge acquisition process in this system is done by interview, discussion, and filling questioner. The acquisition begins with a literature study and then compiled the core question and acquisition framework to the expert.

Acquisitions are also carried out by taking knowledge from literature sources and then confirming to experts based on the results of literature studies. Based on this acquisition process, we obtained knowledge related to the variables that affect the level/type of intelligence in children as input variables. The output variable is a type of intelligence that is owned by a child. The variables used in this study consist of 25 input variables and 9 output variables.

2.4. Knowledge Representation

Knowledge gained from the acquisition process is then represented to form a knowledge base. The knowledge base consists of the intended knowledge and the specifications of the subject matter to be resolved. The method of knowledge representation used in this system is fuzzy representation. Fuzzy representation is used because the environmental factors as inputs on this system have the nature of ambiguity and uncertainty. The integration of expert systems with fuzzy systems is known as the fuzzy expert system. The system is an expert system development that uses overall fuzzy logic, which includes the fuzzy set, the fuzzy if-then rule, and the inference process. Each characteristic variable of intelligence possessed by a child has different rules, so the total rules on this system amount to 81 rules. This rule is obtained based on knowledge acquisition process which obtained from literatures and discussions with experts.

2.5. Inference Machine Development

The inference engine is a component of an expert system that directs knowledge from the knowledge base to reach conclusion. The inference process of this system uses the Mamdani method. In this method, both antecedents and consequences are fuzzy sets. Mamdani method has advantages such as: more intuitive, more accepted by many parties, and more suitable if input is received from humans (not machines) [11]. Mamdani's fuzzy inference process is done in four steps [12]:

1. Fuzzification of input variables. At this stage the input is calculated the degree of membership to each fuzzy set.
2. Evaluation of rules
3. Output aggregation result of rule evaluation
4. Deflate the fuzzy set of outputs to a single value (crisp).

2.6. Implementation and Testing

System was developed by application to create fuzzy model. Testing is done by experts' examination. The purpose of this phase is to check whether the expert system built has adequately represented the human expert. Stages of activity can be repeated on the acquisition process to increase knowledge, improvement on knowledge representation, or improvement on inference machine if the system is not enough to represent human expert.

3. System modeling

We design this expert system using 25 input variables, i.e.: (1) Way of thinking, (2) Memorization, (3) Verbal ability, (4) Counting ability, (5) Logic, (6) Interest to computer subject, (7) Map and graphic reading ability, (8) Imagination, (9) Painting ability, (10) Musicality, (11) Sensitivity to rhythm and tone, (12) Body control, (13) Craft making ability, (14) Creativity

and Activity level, (15) Socializing ability, (16) Mediating ability, (17) Self-motivation level, (18) Self-awareness level, (19) Self-confidence, (20) Awareness to natural phenomenon, (21) Awareness to living environment, (22) Interest to agriculture, (23) Flexibility in solving problems, (24) Leadership, and (25) Ability in solving life-problems.

The output variabels in this system *are:* (1) Verbal Intelligence, (2) Logic/Mathematical Intelligence, (3) Visual/spatial intelligence, (4) Musical intelligence, (5) Kinesthetics intelligence, (6) Intrapersonal intelligence, (7) Interpersonal Intelligence, (8) Naturalis, and (9) Spiritual intelligence. Figure 2 shows the input and output variable used in our system.

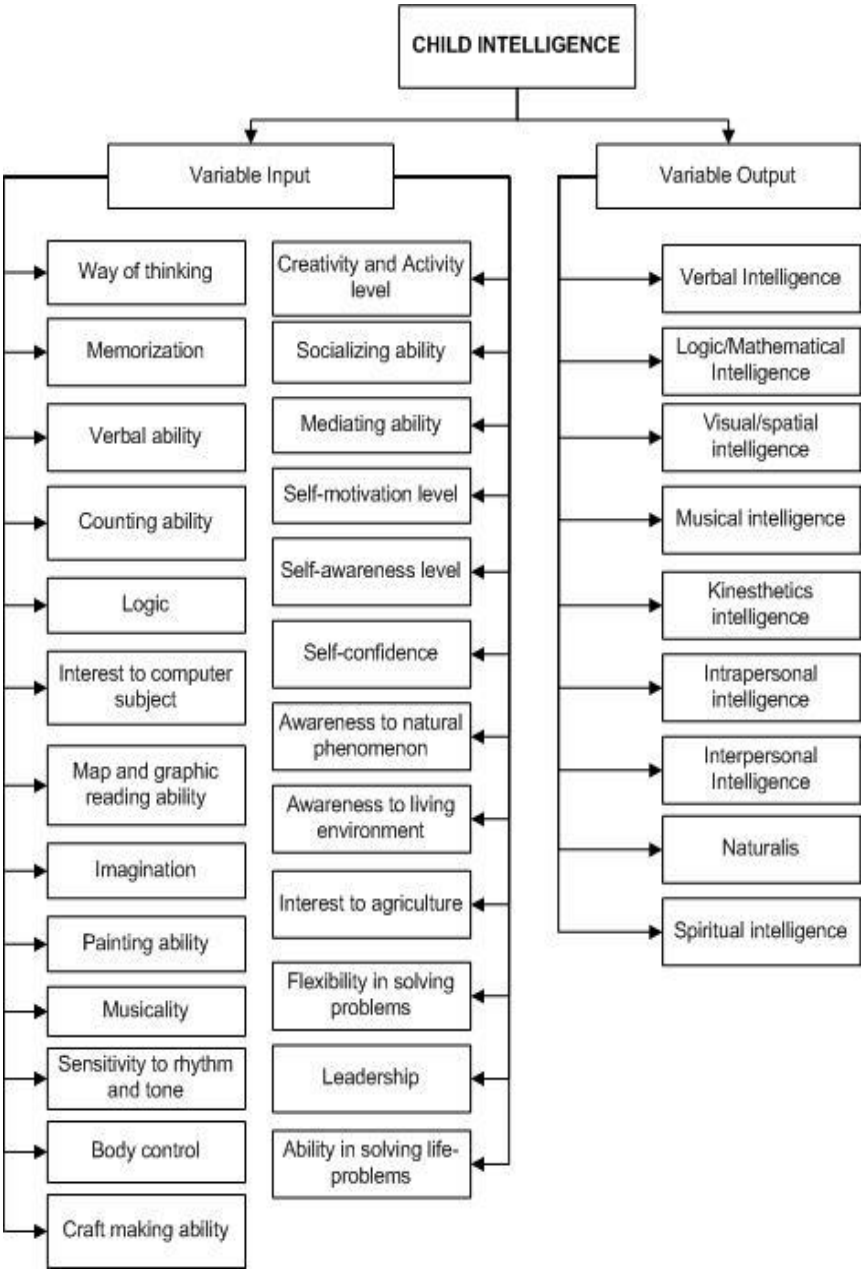

Figure 2. Input and output variables used in the system

The base of knowledge builds using IF-THEN fuzzy rules. The expert system is designed to identify the category of children's intelligence by using fuzzy approach. Table 1 shows the variable related to the assigned fuzzy set in the system.

Table 1. Variables and Fuzzy Set in the System

Variable	Variable Name	Fuzzy Set	Domain	Variable	Variable Name	Fuzzy Set	Domain
Input	Way of thinking	Low	[0,4]	Output	Verbal Intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Memorization	Low	[0,4]		Logic/Mathematical Intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Verbal ability	Low	[0,4]		Visual/spatial intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Counting ability	Low	[0,4]		Musical intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Logic	Low	[0,4]		Kinesthetics intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Interest to computer subject	Low	[0,4]		Intrapersonal intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Map and graphic reading ability	Low	[0,4]		Interpersonal Intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Imagination	Low	[0,4]		Naturalis	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Painting ability	Low	[0,4]		Spiritual intelligence	Low	[0,40]
		Moderate	[1,9]			Moderate	[1,90]
		High	[6,10]			High	[60,100]
	Musicality	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Sensitivity to rhythm and tone	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Body control	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Craft making ability	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Creativity and Activity level	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Socializing ability	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Mediating ability	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Self-motivation level	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Self-awareness level	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Self-confidence	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Awareness to natural phenomenon	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Awareness to living environment	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Interest to agriculture	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Flexibility in solving problems	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Leadership	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				
	Ability in solving life-problems	Low	[0,4]				
		Moderate	[1,9]				
		High	[6,10]				

3.1. Fuzzy Set

Generally, fuzzy set within the system consist of three levels: low, moderate, and high. Fuzzy set used in every input variable is grouped based on three values which are low (0,4), moderate (1,9), and high (6,10) whereas every output variable is grouped into three values which are also low (0,4), moderate (10,90), and high (60,100). Variables functioning as input can be represented by triangular curve and linier representation as follow:

1. Less systematic can be represented by descending linear lines.
2. Moderately systematic can be represented by triangular representation.
3. Very systematic can be representated by ascending linear line representation.

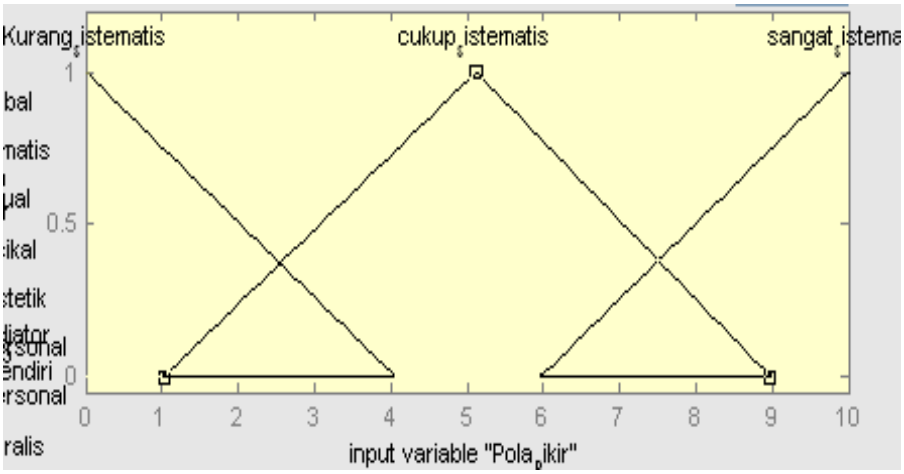

Figure 3. Membership function for 'way of thinking' variable

Way of thinking variable consists of three memberships, as shown in Figure 3, having membership function as:

μ Less systematic [x] =	(4-x)/(4-0);	0≤x≥4
	0;	x≥4
μ Moderately systematic [x] =	0;	x≤1 atau x≥9
	(x-1) / (5-1);	1≤x≤5
	(9-x) / (9-5);	5≤x≤9
μ Very systematic [x] =	0;	x≤6
	(x-6) / (10-6);	6≤x≤10
	1;	x≥10

For example, a child has value equal to 2 in thinking variable will have degree of membership as follows:

μ Less Systematic (4-2) / (4-0) = 0.5

μ Moderately Systematic (2-1) / (5-1) = 0.25

So it can be said that the child has thinking variable equal to less systematic with a membership degree of 0.5 or quite systematic with a membership degree of 0.25. For variables that serve as outputs can be represented using triangular (triangular) curves, with variable of **Verbal Intelligence** consists of three degree of membership as shown in Figure 4:

1. Low can be represented by a downward linear representation.
2. Moderate can be represented by triangular curve representation.
3. High can be represented by upward linear representation.

Membership function is:

μ Low [x] = (40-x)/(40-0); 0≤x≥40
0; x≥40

μ Moderate [x] = 0; x≤10 atau x≥90
(x-10) / (50-10); 10≤x≤50
(90-x) / (90-50); 50≤x≤90

μ High [x] = 0; x≤60
(x-60) / (100-60); 60≤x≤100
1; x≥100

For example, a child has value equal to 70 in verbal intelligence variable will have degree of membership as follows:

μ high (70-60) / (100-60) = 0.25

μ moderate (90-70) / (90-50) = 0.5

So it can be said that the child has verbal intelligence variable equal to moderate with a membership degree of 0.5 or high with a membership degree of 0.25.

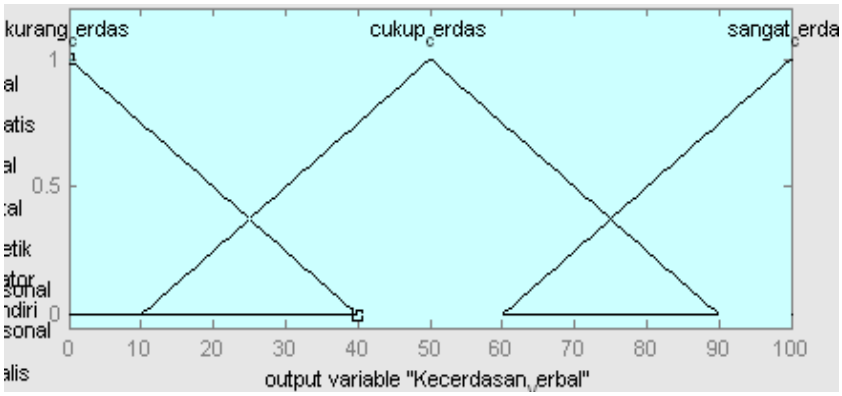

Figure 4. Membership function for 'verbal intelligence' variable

3.2. If-Then Fuzzy Rules

Discussion with experts were conducted to determine rule. As many as 81 rules are obtained. Not all rules are mentioned in this paper and only several rules are taken as example, as shown in Table 2.

3.3. Inference Machine Development

The inference process is performed by applying the Mamdani method. User fills in the inputs for each fuzzy parameter. The input then calculated the degree of membership to each fuzzy set. The degree of membership acquired is then used to evaluate the rules on the knowledge base. The rules on this system are connected by the AND operator so that as consequent values are taken the minimum membership degree of each antecedent for a rule. The resulting consequent values are then aggregated to obtain a set of fuzzy outputs, ie the fuzzy set of effectiveness.

The fuzzy set of children's intelligence is then processed to obtain the crisp value of the child's intelligence identification. The defuzzification method used in the system is the centroid method. The defuzzification process produces a single value output of the child's intelligence

identification. The system also gives the linguistic category output whether the level of intelligence of children including high, moderate and low.

Table 2. Samples of fuzzy rule set of 'way of thinking' variable

R-1		R-2	
IF	Way_of_thinking is very_systematic	IF	Way_of_thinking is less_systematic
AND	Memory is strong	AND	Memory is low
AND	Verbal_ability is high	AND	Verbal_ability is low
AND	Calculation_ability is low	AND	Calculation_ability is very_high
AND	Logic is low	AND	Logic is very_high
AND	Interest_to_computer_subject is low	AND	Interest_to_computer_subject is high
AND	Map_and_graph_reading_ability is lo	AND	Map_and_graph_reading_ability is low
AND	Imagination is low	AND	Imagination is low
AND	Painting_ability is low	AND	Painting_ability is low
AND	Musicality is low	AND	Musicality is low
AND	Sensitivity_to_rhythm_and_tone is low	AND	Sensitivity_to_rhythm_and_tone is low
AND	Body_control is low	AND	Body_control is low
AND	Crafting_abilityis low	AND	Crafting_abilityis low
AND	Socializing_ability is low	AND	Creativity_and_activity is low
AND	Mediating_ability is low	AND	Socializing_ability is low
AND	Self_motivation is low	AND	Mediating_ability is low
AND	Self_conscience is low	AND	Self_motivation is low
AND	Self_confidence is low	AND	Self_conscience is low
AND	Awareness_to_natural_phenomena is low	AND	Self_confidence is low
AND	Awareness_to_living_environment is low	AND	Awareness_to_natural_phenomena is low
AND	Interest_to_agriculture is low	AND	Awareness_to_living_environment is low
AND	Flexibility_in_problem_solving is low	AND	Interest_to_agriculture is low
AND	Leadership is low	AND	Flexibility_in_problem_solving is low
AND	Coping_with_life_problem_ability is low	AND	Leadership is low
THEN	Verbal_intelligence is very_high	AND	Flexibility_in_problem_solving is low
		AND	Leadership is low
		AND	Coping_with_life_problem_abilityis low
		THEN	Mathematical_ability is very_high

34. User Interface

After going through the stage of knowledge representation and inference engine development, implementation of expert system of child intelligence identification is done. The initial view on the system can be seen in Figure 5.

Figure 5. Interface of Child Intelligence Identification Expert System

3.5. Testing

The system's testing is done by comparing the result with the expert judgment. The expert is involved in the testing and validation process to give feedback for refinement purpose.

4. Conclusion

From this research, it can be concluded that child intelligence can be determined through fuzzy method with previous observation on child to understand the child's characteristics. The system applied 81 rules to identify which intelligence possessed by the child. The experts have been involved to obtain knowledge and examine the system. For future works, we will use real data and test the system in real environment.

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