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Data obtaining and system design of diagnosis expert system on children motor skill disorder

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ABSTRACT

Taking children motor skill disorder as example, this essay analyses uncertainty, complexity, velocity of diagnosis expert system data, illustrates the process of diagnosis expert system, including compiling test projects, scale formation, obtaining data and turning into knowledge base. This paper analyses the uncertainty of the initial evidence, give out design of diagnosis expert system for children's motor skill disorder, including knowledge base, evidence base, inference engine and user interface, basing on uncertainty reasoning model of expert system. The essay is of good significance for both diagnosis expert system study and early diagnosis and early intervention of children's motor skill disorder.

KEYWORDS

Diagnosis expert system; Children's motor skill disorder; Uncertainty reasoning; Data obtaining; System design.

INTRODUCTION

Children's cognition of external things and development of wisdom are inseparable with children motor activity. Motor skill disorder affects children learning, as well as their daily life. Research has shown that children motor skill disorder gets a ratio of about 6% in 5-15-year-old children. Therefore early diagnosis and early intervention of children's motor skill disorder are very important.

Diagnosis expert system can obtain measurement data to the user; give correct judgement on skill disorder according to the observed facts. Because this diagnosis expert system is based on uncertain information, the factual knowledge data acquisition is crucial.

At present, in the education activities, teachers have to diagnose whether children have motor skill disorder and which kind of them. Teachers' knowledge level is different about diagnosis of children's motor skill disorder, so it is necessary to develop a diagnosis expert system on children's motor skill disorder. This paper elaborates in detail on key data acquisition and system design.

CHARACTERISTICS OF DIAGNOSIS EXPERT SYSTEM ON CHILDREN'S MOTOR SKILL DISORDER

Motor skill disorder, i.e. Developmental coordination disorder (DCD), refers to difficulties and uncoodinations of action. It is used to state damage on coordination motor development, usually is considered as information abnormal pass because of brain immaturity, such as slow and forgetful. Children affected are described as "clumsy" (David Perlstein, MD, FAAP). Also, motor skill children are accompanied by a certain degree of spatial perception and homework difficulties, such as, they can not give a good grasp of a cup or a ball and make it fall. By study of diagnosis expert system and children's motor skill disorder, we found diagnosis data in the system have the following characteristics.

Uncertainty

Data of diagnosis expert system on children's motor skill disorder is uncertain, which is from uncertainty of expert experience. In expert experience, it is difficult to judge their conclusion by true or false. Usually every observation has a certainty factor degree. For example, the expert judge a child the symptom of instable walking, falling or stumbling, the credibility is 80%. Thus expert system diagnosis shows uncertainty which can't be considered as complete true or complete false. It will conclude uncertainty only by true possibility.

Also, diversity of data source leads data uncertainty. Reasons for motor skill disorder are many and indefinite, including genetic factors, prenatal and perinatal factors, environmental factors, etc. They are not attributed to mental retardation or congenital or postnatal diseases of nervous system.

Complexity

We live in a huge and complex system of the world. The world is complex, its elements are complex, and it has heterogeneity. Its structure is complicated, not only on the permutation and combination of the elements, but also on the cell, tissue, organism, population and other complex hierarchy. Children's motor skill disorder also have many different types, with various symptoms. For example, according to the completion of motor skill involved muscle groups. Motor skill can be divided into gross motor skill and fine motor skill. Gross motor skill is those skill completed by large muscle groups, such as running. Fine motor skill is those completed by small muscle groups, such as writing. Therefore data of diagnosis expert system based on children motor skill disorder is complicated.

Velosity

Diagnosis expert system data come from accumulation of experts' long-term experience. It needs large amount of experience. These experience are not complete, must be constantly updated and supplemented. Meanwhile, children motor skill disorder shows sorts of new symptoms. So diagnosis expert system database must continue to update the data.

ACQUISITION OF DATA

In diagnosis expert system, the factual knowledge data acquisition is crucial. This determines the quality and efficiency of the system. To do this, we must do:

Make sure the purpose of acquisition of data

In china researchers and achievements are mostly concentrated in medicine. From signalment, screening and diagnosis to counseling and treatment, they are specialized. Non professional people will not enter the field. In some big cities such as Beijing, Shanghai, Guangzhou, Xi'an, Nanjing there are special agencies for orthodontic treatment and effect evaluation by professional personnel.

In practice, diagnosis of children motor skill disorder must be carried out by teachers in educational front line. To help these children with disorders has been a very urgent and difficult problem to solve for our education researchers, teachers and parents. To improve the situation of these children to learn in recent years, many scholars at home and abroad has done many studies in this area. In contrast, the domestic research in this area lags behind the theoretical system and is not sound enough.

Therefore, the purpose of obtaining diagnosis expert system data based on children motor skill disorder is to make ordinary teachers diagnose children motor skill disorder by expert data and expert level and provide targeted intervention support. This will be very meaningful.

Compile test project

Artificial Intelligence Expert System development has entered a very high level. Diagnostic expert system has also made remarkable achievements. But research on expert system on children motor skill disorder used to diagnosis whether children have motor skill disorder and which kind of them is seldom.

Experts in the field of the diagnosis of children motor skill disorder have achieved many accomplishments mainly through the method of scale in the form of questionnaires or tests. But we also face many problems need to solve.

First, make test program by combining authoritative quantitative test standard on children early intervention field, checking relative literature, referring to former description. For example, in Chinese Classification of Mental Disorders-3, it describes motor skill disorder as 3 items, i.e. motor coodination of fine skills or gross skills is apparently lower than the same age children, intelligence is normal or close to normal, not caused by auditory and visual defects, or by nerve, muscle, or joint diseases. Peabody Developmental Motor Scales-second edition consist of Reflex, stationary control, locomotion, object manipulation, grasping, visual-motor integration.

Second, visit experts of children motor skill disorder, cooperate with ordinary teachers, get non professional description on symptom of children motor skill disorder, so that diagnosis data can be used in educational practice by teachers.

Third, the project compiling adopts five-level evaluation method. Each project gives a specific description on certain symptom of children motor skill disorder. According to symptom performance frequency it is divided into 5 levels as "always, often, sometimes, rarely, never". The scale consists of 51 test questions.

Formation of scale

The research makes item analysis on the test questions by criterion of internal consistency, using the soft of SPSS (statistical product and service solutions). In inspection, identify each item discrimination by independent samples T-test, take the highest 27% and the lowest 27% as two extreme groups. For item 1 'Easy to knock things over. Soiled or damaged clothing', T-test results as in TABLE 1. 'Sig.=0.000 in t-test for Equality of Means' shows the high score group and low score group have significant difference, i.e. Item 1 has a higher discrimination.

TABLE 1: Independent samples T-test of item 1

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig (2-tailed)	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	17.17	.000	-3.624	106	.000	-28.4118	-8.3184
Equal variances not assumed			-4.167	77.8	.000	-27.1404	-9.5897

Item 8 results as in TABLE 2. Since Sig.=0.529 in Levene's Test for Equality of Variances, Sig.=0.051 in T-test for Equality of Means, it does not reach the significant difference level. So this item in the scale has no discrimination, should be deleted. Similarly, the research removed item 8,15,28,43, 45,48, six items without significant difference.

Removing these 6 items of low discrimination, conduct exploratory factor analysis EFA on 54 items in the scale. In the first EFA, item 25, 39, 55 were deleted. Conduct the second EFA on the remaining 51 items, draw 5 common factors (see Figure 1), describe as balance disorder, speed disorder, endurance disorder, power disorder, and finger flexibility disorder. These 5 factors' explainable cumulative variance reaches 93.337%(see TABLE 3).

TABLE 2: Independent Samples T-test of Item 8

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
						Lower	Upper
Equal variances assumed	.400	.529	-1.976	106	.051	-9.2864	.0166
Equal variances not assumed			-2.061	105.304	.042	-9.0932	-.1766

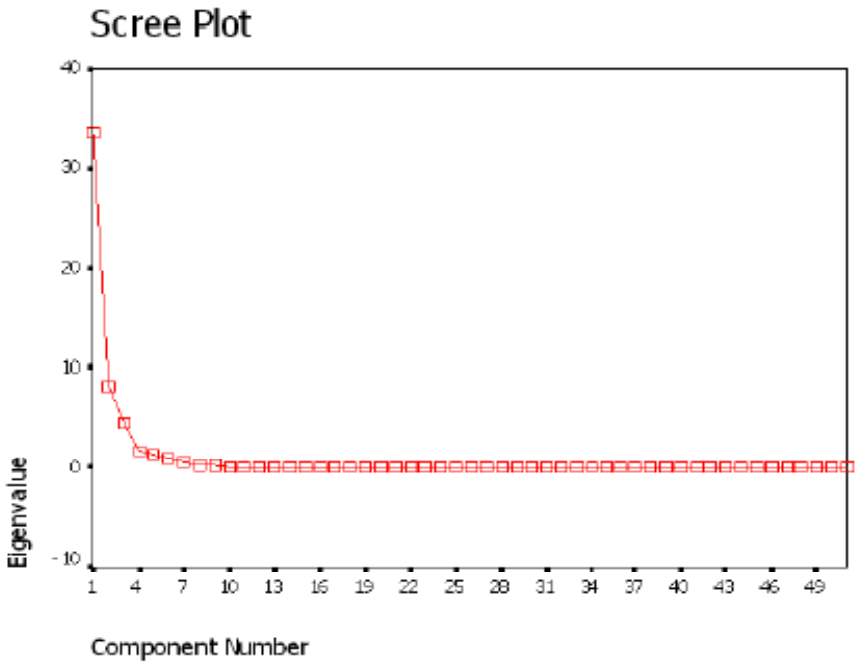

Figure 1: Scree plot of factor analysis

TABLE 3: Total variance explained of factor analysis

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	32.018	62.781	62.781	18.991	37.237	37.237
2	8.415	16.501	79.281	18.228	35.741	72.978
3	5.531	10.844	90.126	6.548	12.839	85.816
4	1.787	3.504	93.630	3.599	7.058	92.874
5	1.381	2.707	96.337	1.766	3.463	96.337

In the empirical investigation, using SPSS test scale reliability, we analyze consistency reliability of the scale by calculating Cronbach Alpha coefficient. Statistical analysis shows that each Cronbach Alpha coefficient is between 0.785 and 0.866. Total scale coefficient is 0.956, higher than acceptable level; it shows the scale has high reliability.

The scale consulted research achievement both at home and broad, it is considered a better representation by relative experts. The research analyses the correlation between each factor and the scale. The results show the correlation coefficient is between 0.286 and 0.515, it shows the independence between each factor. The correlation coefficient between factors and the scale is 0.856 to 0.893, it shows internal consistency is fine.

Transformation of data in the diagnosis expert system

There are many kinds of knowledge representation method in artificial intelligence and each method has its own characteristics. We must choose the most suitable mode for knowledge representation in children motor skill disorder diagnosis.

Uncertain knowledge representation is one of the most active areas in AI research field. Any intelligent system must have uncertainty reasoning ability before it comes to real practical use. As knowledge about children motor skill disorder diagnosis comes with uncertainty, complexity and velocity, the evidence and reasoning relevant to the field are uncertain knowledge.

So we have to start with uncertain initial evidence, and reason with uncertainty knowledge. That is to say, the construction of diagnosis expert system on children motor skill disorder must be based on uncertainty reasoning.

Investigating by 53 front-line experienced teachers, using the scale completed, the teachers observed them meticulously, then evaluate every child's 51 symptoms from 'always' to 'never' all 5 levels, according to the specific condition of every child in this class.

Assume the case that children suffer from motor skill disorder is H, children's 51 symptoms behave as E_i(i=1,2,3....51). In the investigation, sign the probability of children suffering motor skill disorder as P(H), the probability of children performance some symptoms as $P(E_i)$, and sign children performance some symptoms while suffering from motor skill disorder(H) as $P(E_i/H)$. Thus infer the value that the children have some symptoms (E_i) conditions with motor skills disorders (H) probability P (H/E_i).

$$P(H/E_i) = P(E_i/H) \times P(H)/P(E_i) \quad \textbf{(1)}$$

In the diagnosis expert system, certainty factor CF formula is

$$CF_i(H, E_i) = \frac{P(H/E_i) - P(H)}{1 - P(H)} \quad P(H/E_i) \geq (H) \quad \textbf{(2)}$$

$$CF_i(H, Ei) = \frac{P(E_i/H) \times P(H) - P(E_i)P(H)}{P(E_i) - P(E_i)P(H)} \quad \textbf{(3)}$$

$$P(H/E_i) \geq P(H)$$

In the diagnosis expert system, CF formula can be revised as formula (3), then changed into formula (4). In (4), probability data have been obtained through empirical investigation. So in the study, calculated the needed credibility of reasoning in the diagnosis expert system CF_i(i=1,2,.....51), their range is [0,1].

$$CF_i(H,Ei) = \frac{P(H) \times (P(E_i/H) - P(E_i))}{P(E_i) \times (1 - P(H))} \quad P(E_i/H) \geq P(E_i) \tag{4}$$

Regularization of data in the diagnosis expert ssystem

The formation process of diagnosis knowledge about children motor skill disorder is very complex. It must be generated through the following five stages. There are four stages in it.

The first stage is the knowledge of problem. It is about how to identify children motor skill disorder diagnostic problem and mainly about the identification of problem, the definition of problem, and the task analysis and data collection in the typical issue.

The second stage is the conceptualization of knowledge. This is relevant to the key concepts and their relations for children motor skill disorder diagnosis. This mainly includes identifying the main data types, clarifying the known conditions and target, raising the basic hypotheses and the control strategies.

The third is the formation of concept. It consists of selecting knowledge representation method and transforming key concepts or information flow to formal expression. It is the progress of the determination of the data structure.

The forth stage is regularization of formation. That is the formation of rules in which formalized motor skill disorder diagnostic knowledge is transformed to programming language so it can be identified for computer.

After the above-mentioned procedure, knowledge representation mode comes into being in diagnostic expert system for motor skill disorder.

The knowledge we have satisfies the requirements including a unitary structure model, a coherent symbol pattern, combination of both. So children motor skill disorder diagnostic knowledge can be represented with the three levels system expressed by “concept -fact -rule". It divides the children motor skill disorder diagnostic knowledge into three parts of concept knowledge, fact knowledge and rule knowledge.

Concept knowledge is the basic content of diagnostic knowledge. Professionals in the field of children motor skill disorder begin with the definitions and discuss the types of it. They give confirmation and classification; find out the various diagnostic characteristics, the nature and essence, as to classify symptoms which have the same essence or nature as one category.

Fact knowledge set up the links between concepts. Professionals describe characteristics of measurable symptoms into scale that be chosen yes or no, or asked for self explanatory.

Rule knowledge is used to judge the type of motor skill disorder according to the credibility factor. After analyzing the performance of children according to the scale, the accuracy and reliability of the results should be measured. Thus we can determine whether children have any type of motor skill disorder.

DATA APPLICATION IN UNCERTAINTY REASONING

The so-called reasoning is a process that infer conclusion from the known fact in some strategy. That including two kinds of facts, one is the initial evidence related to solving problems, the other is the middle conclusion getting in the reasoning process. In the diagnostic expert system based on children motor skill disorder, all the data related to children motor skill disorder will be saved in data base. When the expert system start working, it will save the data of children’s symptoms to the fact base, then starting from this initial evidence, find matchable data according some tactics. The obtained

intermediate results will be put into fact base as new facts, continue to search for matchable data, so repeatedly, until reasoning the final conclusion.

In this process, reasoning method is critical. Since most things in the real world all have some degree of uncertainty, it is not possible to completely eliminate from the world we live in. These things are difficult to indicate and process with accurate mathematical model. It is because of the existence of uncertainty that our understanding of the past and prediction of the uncertain future are always vague, so with the diagnosis of children motor skills disorder. We start from uncertain initial evidence, using uncertain data, patient reasoning, then complete diagnosis of disorder. This is called uncertain reasoning.

Uncertain representation of initial evidence

As mentioned above, in uncertain reasoning, there are two kinds of evidence, one is initial evidence in solving problem, the other is intermediate result in reasoning.

In the nature and human society, most phenomenon are random events, seldom are precise events (absolute true or false). The human description of this kind of natural and social phenomenon is fuzzy, it is difficult to express accurately. That is to say, the related symptom of disorder children is uncertain, with objective randomness.

On the other hand, in the diagnosis expert system of motor skill disorder, experts judge children symptom by never, rarely, sometimes, often, always 5 degrees. This evaluation and description is vague or subjective uncertainty. So the value of CF in expert system initial evidence is subjective judgement of expert by facts, and is not certain. Its uncertainty can be expressed by credibility CF (Ei), the value range is [0, 1].

If $CF(E_i) = 1$, the credibility is 1, says the evidence is true

If $0 < CF(E_i) < 1$, the credibility is (0,1), says the evidence trueth is $CF(E_i)$

If $CF(E_i) = 0$, the credibility is 0, says the evidence is false.

In the diagnosis expert system on children motor skill disorder, for uncertainty of children performance and experts judgement and description, use probability p to represent credibility of evidence $CF(E_i)$. We define "never" as small probability event, the probability is 0.05, define "always" as big probability event, the probability is 0.95. Thus we revise credibility range $0 \le CF(E_i) \le 1$ as $0.05 \le CF(E_i) \le 0.95$.

In the maximum entropy model, probability is in uniform distribution, the entropy is maximum. In expert system membership function of evidence under this principle $y=f(x)=kx=0.25x$, this function is homogeneous function.

When initial evidence is "never", x=0, $CF(E_i) = 0.05$

When initial evidence is "rarely", x=1, $CF(E_i) = 0.25$

When initial evidence is "sometimes", x=2, $CF(E_i) = 0.50$

When initial evidence is "often", x=3, $CF(E_i) = 0.75$

When initial evidence is "never", x=4, $CF(E_i) = 0.95$

Uncertainty reasoning of intermediate eevidence

When matching into intermediate evidence with initial evidence and database, everytime we apply the principle, synthesize CF of the first evidence and the second evidence, then synthesize the second and the third, until into credibility of all evidence. In expert system, in the children learning disorder system, 51 items of data $CFi(H) > 0$. So data 1 and data 2 are synthesized according to formula (4), synthesized with the third data according to formula (6). By analogy, synthesis of evidence i-1 and evidence i follows the formula (7).

$$CF_{1.2}(H) = CF_1(H) + CF_2(H) - CF_1(H) \times CF_2(H) \quad \textbf{(5)}$$

$$CF_{1.2.3}(H) = CF_{1.2}(H) + CF_3(H) - CF_{1.2}(H) \times CF_3(H) \quad \textbf{(6)}$$

$$CF_{1.2.3..i} = CF_{1.2..(i-1)}(H) + CF_i(H) - CF_{1.2..(i-1)}(H) \times CF_i(H) \quad \textbf{(7)}$$

TABLE 4: Database of diagnosis on children motor skill disorder

Disorder (THEN H)	Symptom,(IF Ei)	CF(H, Ei)	frequency	Probability (Ei)
Disorder 1-5	Easy to knock things over. Soiled or damaged clothing	CF_1= 0.39	often	0.75
	Movement clumsy, uncoordinated, difficult to master motor skill in physical education	CF_2= 0.32	always	0.95
	Difficult to play or catch ball	CF_3= 0.21	sometimes	0.50
	…	…	…	…
	Often out-of-bounds drawing and coloring	CF_{51}=0.11	never	0.05

TABLE 4 contains all 51 data needed in the diagnosis of children motor skills disorders. In each analogy, synthesis of evidence I-1 and evidence of I follows the formula (6). The initial evidence is sent to the following conclusion, which is used to update the conclusion uncertainty, and then reason out the final conclusion.

SYSTEM DESIGN

The diagnosis expert system based on children motor skill disorder contains the following five parts (see Figure 2. Flow Chart of Expert System).

Knowledge database

Knowledge database is a knowledge memory of diagnosis expert system, also called intelligent database, or rule base, which is used for storing field knowledge in solving problem, usually marked by production rule.

In 1943, American mathematician E. Post first proposed the term production rule, this knowledge representation technology imitated the process human thinking, has extensive knowledge representation capability, to describe facts or rules of certainty or uncertainty. For a piece of uncertainty knowledge, any fact can be represented by rule of four tuple (object, attribute, value, credibility factor). If E is knowledge premise, H is knowledge conclusion, CF(H,E) must be the credibility factor. Usually use condition probability P(H/E) to represent probability of H under E condition. That is to say, for certain object, we can express as,

$$\text{IF } E \text{ THEN } H\,(CF(H,E)) \quad \textbf{(8)}$$

In this study, 51 items of data for diagnosis of children motor skill disorder, expressed as 51 production rule in the knowledge base. They are:

IF Easy to knock things over. Soiled or damaged clothing THEN motor skill disorder 0.39

IF Movement clumsy, uncoordinated, difficult to master motor skill in physical education THEN motor skill disorder 0.32

IF Play ball with difficulties THEN motor skill disorder 0.21

IF Often out of bounds in drawing and coloring THEN motor skill disorder 0.11

…

IF E_i THEN motor skill disorder CF_i

Evidence base

Evidence base is called global database or comprehensive database, is used to store relative field problem facts of initial data. In this system, evidence base is to store relative symptoms of children motor skill disorder. The diagnosis will judge children from “always” to “never”5 levels, then read by man-machine interface.

Inference machine

Inference machine is used to control which rule to start and control strategy. In this study, the inference machine inquires and matches initial data Ei in evidence base and rule condition in knowledge base. According to evidence transitivity, in formula (4) calculate evidence credibility CF_i (H), and in formula (7) synthesize it with CF_{i+1} (H) evidence, then put the CF_{i+1} (H) into evidence base.

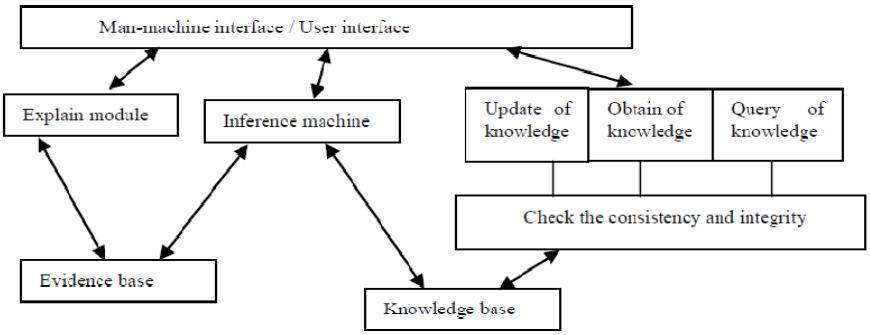

Figure 2: Flow chart of expert system

User interface

User interface is used to exchange information between users (diagnosis, teachers) and expert system. On the one hand, system read children symptoms from man-machine, on the other, system reason by inference machine, transfer diagnosis results to users by interpretation module.

Technical foundation

The emergence of C++ language provides us a good help on program design. It supports objective-oriented design, as well as traditional program design, make the data easy to abstraction, encapsulation, make the system easy to modular, localization and clear structure. It can improve the safety, reliability of the system; make the process simple, easy to modify and maintain. With high efficiency and intelligence of SQL Server 2008, the powerful features of the C++ language provide a powerful technical support for the implementation of the diagnosis system. We develop the Diagnosis Expert System on Children Motor Skill Disorder based on this. It is a practical and convenient tool to diagnosis whether children have motor skill disorder and which kind of them (as see in Figure 3 and Figure 4).

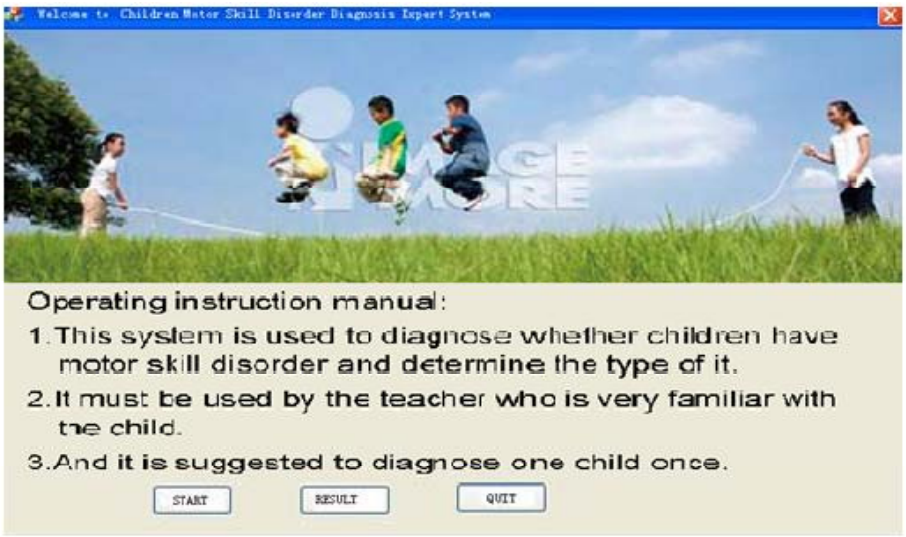

Figure 3: Welcome page

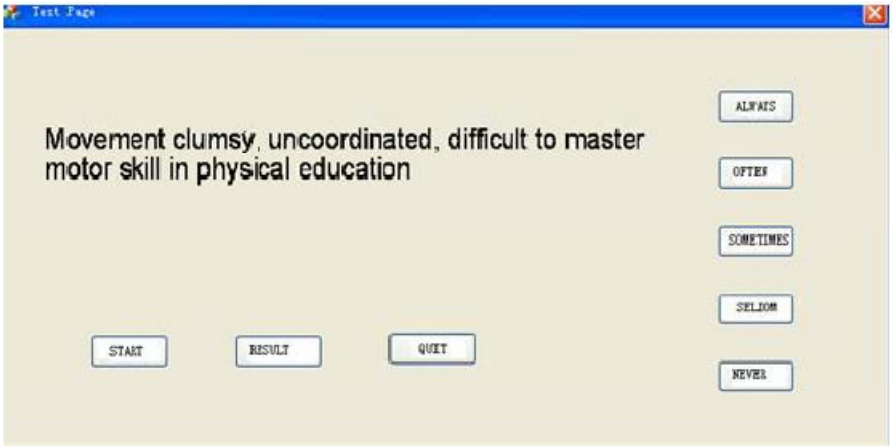

Figure 4: Test page

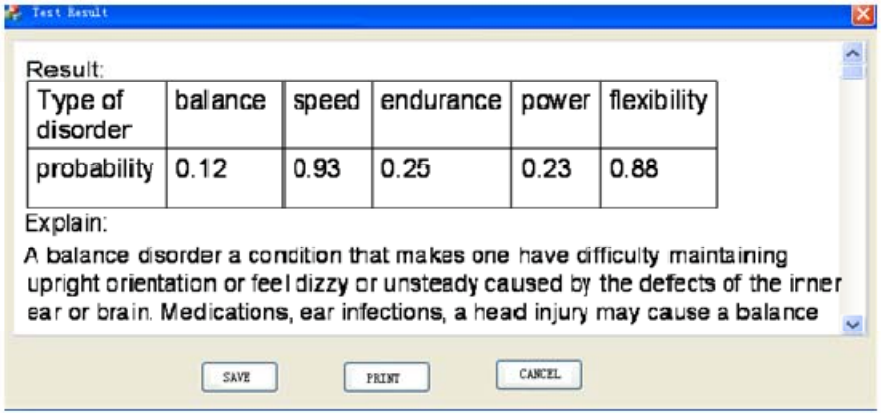

Figure 5: Result page

CONCLUSION

This paper is the first to apply uncertainty reasoning on diagnosis expert system on children motor skill disorder, this research develop and enrich the design theory of the uncertainty diagnosis expert system from the perspective of data obtain and system model, is the reference for the development theories and method of other similar expert system. Researching for the system has significance for the design and development of diagnosis expert system, and for the early diagnosis and intervention for children motor skill disorder.

Meanwhile, this system help normal front line teachers own the knowledge about how to diagnose children motor skill disorder, which support the intervention to the education for children of learning difficulties. It also provides instrumental support for further research on better implement individualized education.

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