Certainty Factor for Early Detection of Children’s Respiratory Disease

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Abstract. The immune system of children are weaker than adults. They are susceptible to diseases. One of the diseases that often affects them is respiratory disease. Expert systems can be used to determine early diagnosis of it. Certainty Factor allows the user to measure the certainty’s degree of the diagnosis. It is also affecting the level of trust. It is easy for users to make decisions in determining the healing step. Symptoms of the disease are analysed and managed into the knowledge base of the expert system. The result of disease diagnosis is appeared in the form of disease data. The result data are accompanied by certainty value or percentage of confidence that obtained by certainty factor method applied.

1. Introduction
Children are groups of age that have a weaker immune system than adults. They are more susceptible to disease. Diseases in children are vary greatly, ranging from mild illness to disease that can cause of death. Actually, the bad impact of it can be prevented, but due to lack of knowledge's parents cause prevention of diseases are not done optimally [1]. Generally, parents tend to directly provide medicine that sold in the market when their children were sick. Their children have a chance to consume an inappropriate medicine that can make them become immune to the substances contained in it. The effect of medicine abuse is very dangerous. Parents are expected to have knowledge about early detection of children disease [2]. By recognizing the various symptoms of the disease, parents can make the right decision whether the child should get further medical treatment or not [3]. Expert systems are only used to help early detection of diseases. When the disease is increasingly worried, parents still have to check to the doctor and provide treatment in accordance with the doctor's advice. Expert systems can solve a particular problem by using special knowledge that possessed by an expert. It is part of artificial intelligence [1]. The components that must be in the expert system are user interface, expert system database, knowledge acquisition facility, and inference mechanism [4][5]. Certainty factor (CFs) is based on the certainty theory. It introduces the concept of trust and unbelief. So, it is definitely not a probability [6]. CFs express confidence in events either in fact or hypotheses based on events or on an expert's judgment. According to Giarattano and Riley in their paper to show the magnitude of trust, we can use Certainty Factors (CF) because it is a clinical parameter value [7]:

\[
CF [H, E] = MB [H, E] - MD [H, E]
\]

CF [H, E] = Certainty factor of hypothesis H which is influenced by Evidence E.
MB [H, E] = Level of certainty in the hypothesis H which is affected by Evidence E.
MD [H, E] = Level of distrust in the hypothesis H which is affected by Evidence E.

One of the common symptoms of respiratory disease is coughing. Cough is a form of defines of the body against the entry of foreign bodies or mucus in the respiratory tract so as not to enter the
lungs. Cough is also a normal thing that often occurs in children. But if excessive, cough can harm the mucosal cells in the airways and can cause sleep disorders [8][9][10].

2. Methodology

In this study the authors use the production rule model or also called the rule-based representation of knowledge model. A production rule is a statement of programming logic that specifies the execution of one or more actions in the case that its conditions are satisfied [11][12][13]. The method used is a fuzzy method where the examples of fuzzy methods vary. One example is c-means. The Fuzzy C-Means algorithm is one of the easiest and often used algorithms in data grouping techniques because it makes efficient estimates and does not require many parameters [14]. There are many method use A Certainty Factor is a numerical value that expresses the extent to which, based on a given set of evidence, we should accept a given conclusion. A Certainty Factor or CF with a value of 1 indicates total belief, whereas a CF with a value of -1 indicates total disbelief. In a system that uses CFs, the rules must be so structured that any given rule either adds to belief in a given conclusion or adds to disbelief [15][16].

| Table 1. Data of diseases |
|---------------------------|
| No | Code | Name of diseases | Information |
|----|------|------------------|-------------|
| 1  | P01  | Pneumonia        | Pneumonia is a lung infection caused by viruses, bacteria, fungi, or mixed infections. In fact, 70% of the causes of severe pneumonia are bacteria. |
| 2  | P02  | Common Cold      | Common Cold or common cold cough is a common viral disease in children. This disease attacks children 3-10 times a year, depending on the condition and the child's immune system. |
| 3  | P03  | Influenza        | Flu or also called Influenza is often used to refer to common cold disease. Influenza is caused by Influenza virus, namely: Influenza A and Influenza B. |
| 4  | P04  | Asthma           | Asthma is a disease characterized by shortness of breath. It is caused by Airway narrowing due to the inflammation process. |
| 5  | P05  | GER and GERD     | Gastroesophageal Reflux (GER) or "spit up" is the increase in the contents of the stomach into the oesophagus. While Gastroesophageal Reflux Disease (GERD) is a GER that is permanent or prolonged and cause a more serious impact. |
| 6  | P06  | Pertussis Level 1| Pertussis is a respiratory tract infection caused by the bacterium Bordetella Pertussis. Pertussis can be transmitted through a splash in the air when the patient coughs or sneezes. |
| 7  | P07  | Pertussis Level 2| Tuberculosis (TB) is an infectious disease caused by Mycobacterium tuberculosis. TB bacteria usually attack the lungs (pulmonary TB), but can also attack other organs called TB Extra lung. |

Diseases and symptoms of diseases caused to respiratory diseases often experienced by children can be seen in the table below:
| No | Code | Name of Diseases | Information |
|----|------|-----------------|-------------|
| 1  |      | Pneumonia       |             |
|    |      | Cough           | 0.7         |
|    |      | Shortness of breath or rapid breathing | 0.7 |
|    |      | Pull the chest wall inside | 0.8 |
|    |      | Fever           | 0.6         |
|    |      | Decreased appetite | 0.6 |
|    |      | Limp            | 0.6         |
|    |      | Diarrheal       | 0.6         |
|    |      | Gag             | 0.6         |
|    |      | Pain in the head | 0.6 |
| 2  |      | Common Cold     |             |
|    |      | Cough           | 0.8         |
|    |      | Sneezing        | 0.8         |
|    |      | Fever below 39 °C | 0.6 |
|    |      | Pain or throat   | 0.8         |
|    |      | Nasal congestion / watery / clear mucus / thick yellowish | 0.8 |
|    |      | Muscle and joint pain | 0.6 |
|    |      | Pain in the head | 0.6         |
|    |      | Red eye         | 0.6         |
|    |      | Decreased appetite | 0.6   |
| 3  |      | Influenza       |             |
|    |      | Fever           | 0.8         |
|    |      | Sneezing        | 0.8         |
|    |      | Dry cough       | 0.8         |
|    |      | Muscle and joint pain | 0.7 |
|    |      | Pain or throat   | 0.8         |
|    |      | Pain in the head | 0.7         |
|    |      | Nasal congestion / watery / clear mucus / thick yellowish | 0.8 |
|    |      | Red eye         | 0.7         |
|    |      | Decreased appetite | 0.7   |
| 4  |      | Asthma          |             |
|    |      | Shortness of breath and wheezing are repeated episodically | 0.8 |
|    |      | Occurs during the night | 0.6 |
|    |      | Occurs after physical activity | 0.8 |
|    |      | There is a history of asthma | 0.8 |
|    |      | Cough           | 0.6         |
|    |      | Allergic dust / animal dander / etc | 0.8 |
| 5  |      | GER and GERD    |             |
|    |      | Child Age 12-14 months | 0.8 |
|    |      | Gag             | 0.8         |
|    |      | Fussy after nursing | 0.8 |
|    |      | Waking up at night | 0.6 |
|    |      | Refuse to breastfeed | 0.8 |
|    |      | Weight loss     | 0.8         |
|    |      | Cough           | 0.6         |
|    |      | Experiencing colic | 0.6 |
|    |      | Swallowing and breathing difficulties | 0.6 |
| 6  |      | GER dan GERD    |             |
|    |      | Child Age 12-14 months | 0.8 |
|    |      | Gag             | 0.8         |
|    |      | Fussy after nursing | 0.8 |
|    |      | Waking up at night | 0.6 |
|    |      | Refuse to breastfeed | 0.8 |
Weight loss 0.8  
Cough 0.6  
Experiencing colic 0.6  
Swallowing and breathing difficulties 0.6  
Vomit is greenish / yellowish / bleeding 0.8  
Child vomiting spraying 0.8  
Fever 0.7  
Limp 0.7  
Diarrhea 0.7  
The stomach looks very bloated 0.7  
Crown looks prominent 0.8  
Cried very hard 0.7  

7  Pertussis Level 1  
Cough 0.8  
Sneezing 0.6  
Pain gets worse during the night 0.4  
Nasal congestion / watery / clear mucus / thick yellowish 0.6  
Fever 0.6  
Decreased appetite 0.4  
The duration of disease is 1-2 weeks 0.8  

8  Pertussis Level 2  
Cough 0.8  
Sneezing 0.6  
Pain gets worse during the night 0.6  
Fever 0.6  
Decreased appetite 0.6  
Nasal congestion / watery / clear mucus / thick yellowish 0.6  
Length of disease 3-6 weeks 0.8  
Cough often with short periods of time while eating or being active 0.8  
The face flushed and looked bluish 0.6  
Hard to breathe 0.6  
Gag 0.6  
Excessive saliva 0.6  
Weight loss 0.6  

9  Pertussis Level 3  
Cough 0.8  
Sneezing 0.7  
Pain gets worse during the night 0.7  
Fever 0.7  
Decreased appetite 0.7  
Nasal congestion / watery / clear mucus / thick yellowish 0.7  
Length of disease more than 6 weeks 0.8  
Repeated illness for several months 0.8  
Fever 0.6  
Decreased appetite 0.4  
The duration of disease is 1-2 weeks 0.8  

10  Tuberculosis  
Cough for more than 3 weeks 0.8  
Coughing up blood 0.8  
Decreased appetite 0.6  
Fever 0.6  
Sweating at night 0.6  
Weight loss 0.6
The basic form of the formula certainty factor of a rule IF E THEN H is as follows:

\[ CF(H, e) = CF(E, e) \times CF(H, E) \]  (2)

CF (E, e) : Certainty factor evidence E which is influenced by the evidence
CF (H, E) : Certainty factor hypothesis assuming the evidence is known with certainty when CF (E, e) = 1
CF (H, e) : Certainty factor hypothesis which is influenced by the evidence e

The value of a certainty factor hypothesis at the time of definite evidence for Pneumonia's disease is:
\[ CF(H, E) = \min\{CF(H, E_1), CF(H, E_2), CF(H, E_3), ... CF(H, E_9)\} \]
\[ = \min\{0.7, 0.7, 0.8, ... 0.6\} = 0.6 \]
\[ CF(E, e) = \min\{CF(E_1, e), CF(E_2, e), CF(E_3, e), ... CF(E_9, e)\} \]
\[ = \min\{0.6, -0.2, -0.6, ... 0.2\} = -0.6 \]

The value of a certainty factor hypothesis is:
\[ CF(H, e) = CF(E, e) \times CF(H, E) = -0.6 \times 0.6 = -0.36 \]

The value of a certainty factor hypothesis at the time of definite evidence for Common Cold's disease is:
\[ CF(H, E) = \min\{CF(H, E_1), CF(H, E_2), CF(H, E_3), ... CF(H, E_{10})\} \]
\[ = \min\{0.8, 0.8, 0.6, ... 0.6\} = 0.6 \]
\[ CF(E, e) = \min\{CF(E_1, e), CF(E_2, e), CF(E_3, e), ... CF(E_9, e)\} \]
\[ = \min\{0.6, -0.2, -0.2, ... 0.2\} = -0.2 \]
The value of a certainty factor hypothesis is:

\[
\text{CF}(H, e) = \text{CF}(E, e) \times \text{CF}(H, E) = -0.2 \times 0.6 = -0.12
\]

The other calculation was skipped with the same formula and the calculation result using certainty factor method yields the following conclusion:

| No. | Disease | CF Hypothesis |
|-----|---------|---------------|
| 1   | P1      | -0.36         |
| 2   | P2      | -0.12         |
| 3   | P3      | -0.48         |
| 4   | P4      | -0.6          |
| 5   | P5      | 0.36          |
| 6   | P6      | 0.49          |
| 7   | P7      | -0.16         |
| 8   | P8      | -0.12         |
| 9   | P9      | -0.24         |

The table above illustrates the diagnosis using certainty factor method. P6 or GER and GERD disease (hard) is a disease that has the highest CF value. Therefore, the possibility of disease suffered by the patient is GER and GERD (hard) disease.

4. Conclusion

This study yields several conclusions as described below:

1. Analysis of symptom yielded 48 symptoms divided into 10 categories of disease.
2. Method of certainty factor successfully applied to the expert system of child disease diagnosis.
3. Diagnosis results show that GER and GERD (hard) disease has the highest CF value.
4. The possibility of patients suffering from GER and GERD (hard) is 0.49 or 49%.

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