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Certainty Factor Method for an Expert System for Orthopedic Disease Diagnosis

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Abstract

Health is an important thing in human survival, including bone disease. Some people think that bones are passive, dead tissue, but they are not. Bones and skeleton are a very important part of orthopedics. Bones are not only a framework that strengthens the body but are also part of the structure of joints, as protection for the body, where the ends of muscles are attached. One of the diseases that is widely felt in society is bone disease. Bone disease is a condition that damages the skeleton and makes bones weak and susceptible to fractures. The high rate of diseases that attack the bones is caused by the conditions and behavior of society, such as stress, lack of exercise, wrong diet. Another cause is also ignorance and lack of knowledge about bone disease itself. By using an expert system, patients can save time going to the hospital, because the system replaces experts in their field, especially chiropractors. The method that will be used in this research is the Certainty Factor Method. The results obtained later are diagnostic results based on the symptoms entered and issued in the form of decisions and percentages. The diagnosis results identified Cervical Spondylosis (Nerve Pain) with a confidence level of 89.60%. It is hoped that this expert system will make it easier for patients to diagnose bone disease and carry out initial treatment in treating the disease.

Keywords: Expert Systems, Bone Disease, Diagnosis , Certainty Factor, Orthopedics.

1. Introduction

Health can be described by physical conditions and mental functions that can work well. Health is important in human survival. A healthy body can make it easier to carry out various kinds of activities without problems. With good conditions, daily life will be calmer and productivity will increase [1].

Health is an important thing in human survival, including bone disease. Some people think that bones are passive, dead tissue, but they are not. Bone is living tissue and grows, and continuously breaks down, re-forms and repairs its tissue [2].

Bones and skeleton are a very important part of orthopedics. Bones are not only a framework that strengthens the body but are also part of the structure of the joints, as protection for the body, a place for attachment of the ends of muscles which are attached to bones with constant or stable movement during contraction (origo), the ends of muscles which are attached to bones with steady movement change position during contraction (insertion) and the muscles that move the body frame [3].

One of the diseases that is widely felt in society is bone disease. Bone disease is a condition that damages the skeleton and makes bones weak and susceptible to fractures. The high rate of diseases that attack the bones is caused by the conditions and behavior of society, such as stress, lack of exercise, wrong diet. Another cause is also ignorance and lack of knowledge about bone disease itself [4].

From this problem, as the development of technology and information systems grows rapidly, computers are used and utilized as a medium to provide information and improve the performance of human knowledge. One area that can be utilized in this case is the Expert System. An expert system is a computer system that can imitate the abilities of an expert. An expert is someone who has special skills and can solve certain problems that cannot be solved in general by lay people. Expert systems can combine inference rules with a knowledge base that comes from one or more experts in a particular field [5][6].

One method that can be used to overcome uncertainty is the Certainty Factor method. Certainty Factor is a method that defines a measure of certainty regarding facts or rules to describe an expert's confidence in the problem at hand. Certainty Factor shows a measure of certainty regarding a fact or rule[7][8][9].

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Research on expert systems in various fields has been widely carried out. The following are several references used as references in this research.

Ratniasih conducted research on an Expert System for Diagnosing Meningitis Using the Naïve Bayes Method. Meningitis is a deadly disease for sufferers. This disease is caused by bacteria, viruses or fungi. Lack of information about the symptoms of meningitis and the lack of information about this disease are the main causes of the high death rate among the community. So we need a system that can provide information about meningitis. Therefore, there is a need for an expert system to help the public obtain information about the symptoms of meningitis and solutions [10]

Agustino also conducted research on expert systems related to the world of health, namely for diagnosing kidney disease. The development of computer software technology, which has developed rapidly and is followed by the development of artificial intelligence technology, allows an expert system to run on websites using PHP applications. This expert system is expected to be able to provide information on all matters related to kidney disease problems quickly and efficiently in a reciprocal manner for both the user and the system but still optimally [11].

Hidayat, et al diagnosed diseases caused by smoking using the implementation of an expert system. Cigarettes are objects that have various sources of disease if we smoke them directly or inhale the smoke. In a cigarette there are more than 4000 chemicals, of which 200 are dangerous to humans, and 40 of which cause cancer. Smoking can cause changes in the function, tissue structure and respiratory tract of the lungs. The system used in writing this final assignment is an expert system for diagnosing diseases caused by smoking and the method used is Forward Chaining [12].

From the research described above, this research was carried out using expert system technology. This Expert System aims to be able to help the wider community to diagnose bone symptoms. In an effort to obtain high calculation accuracy so that the final results obtained are optimal, the Certainty Factor method is used using symptom weights selected by the user.

2. Research methodology

In preparing research, it is necessary to have a framework structure with clear stages, this framework is used to solve a problem that is being discussed by the researcher, the framework is in Figure 1.

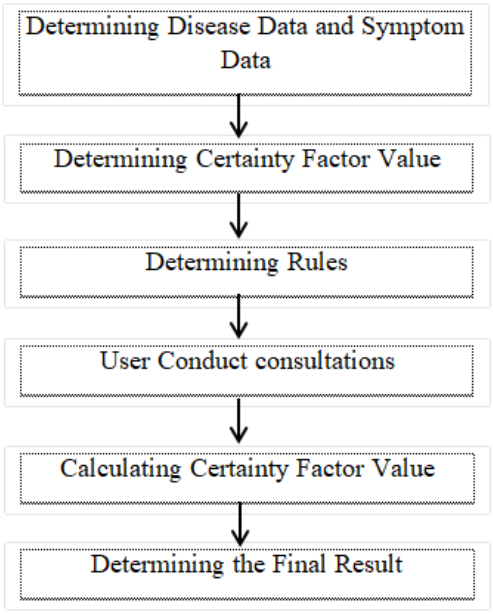

Figure 1. Research Framework

The process of calculating the level of confidence begins by decomposing a rule that contains several symptoms into a number of rules that only involve one symptom. After that, each new rule will be assessed using a specific formula to calculate the Certainty Factor (CF) value.

$$CF(H,E) = CF_{(user)} * CF_{(rule)}$$

Among the conditions that occur, there are several conditions that have the same result (in different rules), we need to collect or combine the Certainty Factor (CF) values from each existing condition to get the overall CF value using the following equation:
If both CF > 0 , then the formula is:

$$\boldsymbol{CF[H,E] = CF_{[lama]} + CF_{[baru]}\,(1 - CF_{[lama]})}$$

If both CF < 0 , then the formula is:

$$\boldsymbol{CF[H,E] = CF_{[lama]} + CF_{[baru]}\,(1 + CF_{[lama]})}$$

If both CF < 0 , then the formula is:

$$\boldsymbol{CF[H,E] = CF_{[lama]} + CF_{[baru]} / (1 - min\,CF_{[lama]} | CF_{[lama]})}$$

The diagnosis results provided by the expert system are the percentage of possible diseases. Determining the disease to be used as a diagnosis is based on the largest percentage among all the diseases evaluated. This disease percentage is generated from calculating the Certainty Factor value based on the symptoms selected by the user.

3. Results and Discussion

3.1 . Data analysis

The data analysis stage is the most important stage in developing a system, because at this stage an evaluation will be carried out to identify existing problems, system design and the steps needed for the desired design to arrive at the expected analysis. The data variables obtained are a collection of types of disease, disease symptoms and solutions or ways of treating them obtained from various sources such as the results of interviews with doctors at Semen Padang Hospital as well as journals and the internet. The following data will be used as research objects:

1. Symptom Data

The symptom data used in the expert system for diagnosing bone disease includes 26 symptoms. The symptoms of bone disease can be seen in Table 1

Table 1. Symptom Data

No	Symptom Code	Symptom
1	G001	Pain in bones/joints
2	G002	Feeling hot in the painful area
3	G003	There is swelling/lump in the area that feels hot and painful
4	G004	Symptoms of inflammation, weight loss, fatigue and decreased ability to carry out activities appear
5	G005	There is a history of falling before
6	G006	Swelling/lumps create limited movement which causes pain
7	G007	There is a tendency for height to decrease
8	G008	Experiencing menopause
9	G009	Pain in the wrist and groin
10	G010	Pain in the spine/back
11	G011	Pain from the arms to the hands and even tingling in the fingers
12	G012	There is pain and tenderness in the cervical spine
13	G013	Burning sensation in the neck, especially at night
14	G014	Pain radiates around the ears and eyes
15	G015	Headaches are sometimes accompanied by migraines and vertigo
16	G016	The pain at the top of the shoulder feels gripping, sometimes reaching the chest
17	G017	Pain feels like an electric shock in the hands and feet
18	G018	Pain in the lower back (waist)
19	G019	Severe pain in the lower back (waist) after bending/lifting
20	G020	Pain when sitting for a long time, standing and walking
21	G021	Pain spreads to the thighs, knees, calves and soles of the feet
22	G022	Feet often tingle
23	G023	History of falling down
24	G024	Pain at night and joint stiffness in the morning
25	G025	Easily tired and weak
26	G026	Decreased joint flexibility

2. Disease Type Data

The number of diseases processed in the bone disease diagnosis expert system is five types of disease, as in Table 2

Table 2. Data on Types of Disease

No	Disease Code	Disease
1	P001	Osteosarcoma
2	P002	Osteoporosis
3	P003	Cervical spondylosis (pain in the cervical spine)
4	P004	Low Back Pain (low back pain)
5	P005	Osteoarthritis

3. Solution Data

From the disease data above, there are several solutions that can be done if you suffer from this disease, as in Table 3

Table 3. Solution Data

No	Disease	Solution
1	Osteosarcoma	a. The operation aims to remove all the cancer. Depending on the size of the tumor and its location, the doctor can perform surgery to only remove the cancer or also remove muscle and other tissue affected by cancer. b. Chemotherapy is the administration of two or more drugs to kill cancer cells. The medication given can be in the form of pills, infusion, or a combination of both. Chemotherapy can be done before surgery to shrink cancer cells so they are easier to remove. The length of chemotherapy a patient needs to undergo depends on the extent of the spread of the osteosarcoma. For osteosarcoma that has not spread widely, your doctor may recommend chemotherapy several months before surgery. Chemotherapy after surgery is done to kill any remaining cancer. c. Radiotherapy is a therapy that uses X-rays or proton rays to kill cancer cells. This therapy is carried out by directing high levels of radiation beams to the part of the body where the osteosarcoma is located. Radiotherapy is performed on patients who cannot undergo surgery or if there are still remaining cancer cells.
2	Osteoporosis	a. The osteoporosis treatment that will be given depends on the severity. If osteoporosis sufferers are at high risk of experiencing bone fractures, doctors can prescribe drugs to increase bone density, such as bisphosphonates, monoclonal antibodies and hormone therapy. b. If necessary, osteoporosis sufferers can be given drugs that can increase bone formation, such as *teriparatide* and *abaloparatide.* c. Patients will also be advised to reduce activities that could cause falls or injury. To be safer, elderly patients with osteoporosis should also live in homes that are safe for the elderly .
3	Cervical spondylosis (pain in the cervical spine)	a. Cervical spondylosis sufferers who have mild symptoms are usually advised to take over-the-counter pain relievers, for example paracetamol . b. However, if the sufferer's pain and other complaints feel increasingly severe, the doctor can prescribe medication to relieve the symptoms of cervical spondylosis. Some types of medication that a doctor may prescribe are non-steroidal anti-

		inflammatory drugs (NSAIDs), such as ibuprofen or naproxen , to reduce pain and inflammation. Corticosteroid drugs , such as prednisone injection, to reduce inflammation, so that they can relieve complaints and symptoms. Muscle relaxants, such as eperisone or chlorzoxazone, to reduce muscle tension that occurs due to cervical spondylosis. Anti-seizure medications, such as pregabalin and gabapentin, to reduce pain due to irritation of the nerves. Tricyclic antidepressant drugs, such as amitriptyline, to reduce chronic pain due to cervical spondylosis. Opioid pain relievers, such as oxycodone , are used to reduce pain that is severe and does not decrease after being given other types of drugs. c. Independent care at home, such as compressing the neck with warm or ice water, using a neck brace, doing light exercise that does not involve regular movement of the neck, avoiding bending, turning or looking up, avoiding sitting or standing for too long, choosing a chair. which is comfortable to sit.
4	Low Back Pain (low back pain)	Initial steps that can be taken at home to relieve symptoms and prevent recurrence of lower back pain are: a. Exercise regularly, especially those that train your abdominal and back muscles. Types of exercise that are good for back pain are yoga , Pilates , walking and swimming . b. Maintain body posture. A straight body posture when sitting or standing can reduce excess pressure on the muscles and spine. c. Reduce weight . Excess weight will put greater stress on the muscles of the lower back and spine. d. Avoid stress. e. Quit smoking. Cigarettes can disrupt the flow of blood vessels in the spine , and slow healing of back pain. f. Give a cold compress to the back. To do this , wrap the ice in a cloth, then apply it to your back for 15-20 minutes. Three days after back pain appears, replace it with a warm compress. g. Improve sleeping position . It is recommended to sleep with your feet slightly elevated. You can try propping your legs up with a pillow while sleeping to reduce pressure on your back. h. Avoid lifting heavy objects, so that lower back pain does not reappear. After the diagnosis of low back pain and the cause are known, the new doctor can provide appropriate treatment, including: a. Pain relievers, severe lower back pain often requires pain relievers from a doctor, for example NSAIDs , either in the form of oral or topical medication. b. Muscle relaxants, this type of drug can treat muscle stiffness due to excessive muscle work. Muscle relaxants may also be given if lower back pain is accompanied by muscle spasms. c. Physiotherapy and physical exercise, physiotherapy with heat, ultrasonic waves, or electrical stimulation (electrical therapy) can help overcome back pain. After the pain is resolved, physiotherapy can be continued with special movement exercises to increase the strength and flexibility of the back muscles. d. Acupuncture, this alternative therapy is believed to help reduce lower back pain. The results will be better if acupuncture is combined with physiotherapy and medication. e. Spinal surgery, in serious cases, such as spinal structural abnormalities or pinched nerves that do not improve with treatment, surgery can be performed to correct abnormalities in the nerves and spine.
5	Osteoarthritis	a. To relieve pain and inflammation the doctor will give medicines, such as paracetamol, non-steroidal anti-inflammatory drugs such as ibuprofen, capsaicin cream, injections of corticosteroid drugs. b. Apart from giving the medicines above, osteoarthritis can also be treated with physiotherapy to strengthen the muscles around the joints, this method can also increase the flexibility of the joints and muscles, and reduce pain and surgery can be done to repair or replace damaged joints. sufferers can move more easily. Examples are total hip replacement in hip osteoarthritis and total knee replacement in knee osteoarthritis. c. Apart from treatment provided by a doctor, osteoarthritis sufferers are advised to adopt a healthy lifestyle, such as regular exercise and losing weight.

4. Relationship between Disease and Symptoms

The following is the relationship between disease and symptoms which can be seen in table 4 below:

Table 4. Relationship between disease and symptoms

Symptom Code	P001	P002	P003	P004	P005
G001	√	√	√	√	√
G002	√				
G003	√				
G004	√				
G005	√				
G006	√				
G007		√			
G008		√			
G009		√			
G010		√			
G011		√			
G012			√		
G013			√		
G014			√		
G015			√		
G016			√		
G017			√		

Symptom Code	P001	P002	P003	P004	P005
G018				√	
G019				√	
G020				√	
G021				√	
G022				√	
G023				√	
G024					√
G025					√
G026					√

		long time, standing and walking	
		G021: Pain radiates to the thighs, knees, calves and soles of the feet	0.6
		G022: Feet often tingle	0.8
		G023: History of falling down	0.8
5	Osteoarthritis	G001: Pain in bones/joints	0.6
		G024: Pain at night and joint stiffness in the morning	1
		G025: Easily tired and weak	0.8
		G026: Decreased joint flexibility	0.6

3.2 Process Analysis

The process stage uses the certainty factor method calculation where the symptoms of bone disease have an expert CF value. Diseases, symptoms and expert CF values used in this study can be seen in table 5 below:

Table 5. Diseases, Symptoms and Expert CF Values

No	Disease	Symptom	Expert CF
1	Osteosarcoma	G001: Pain in bones/joints	0.6
		G002: Feeling hot in the painful area	0.6
		G003: There is swelling/lump in the area that feels hot and painful	1
		G004: symptoms of inflammation appear, weight loss, fatigue and decreased ability to carry out activities	0.8
		G005: there is a history of falling before	0.8
		G006: Swelling or lump limits movement which causes pain.	1
2	Osteoporosis	G001: Pain in bones/joints	0.6
		G007: There is a tendency for height to decrease	0.8
		G008: Experiencing menopause	1
		G009: Pain in the wrist and groin	0.8
		G010: Pain in the spine/back	0.6
		G011: Pain from the arms to the hands and even tingling in the fingers	0.6
3	Cervical spondylosis (pain in the cervical spine)	G001: Pain in bones/joints	0.6
		G012: Presence of pain and tenderness in the cervical spine	1
		G013: Burning sensation in the neck, especially at night	0.8
		G014: Pain radiating around the ears and eyes	0.6
		G015: Headache sometimes accompanied by migraine and vertigo	0.6
		G016: The pain at the top of the shoulder feels gripping, sometimes reaching the chest	0.6
		G017: Pain feels like an electric shock in the hands and feet	0.8
4	Low Back Pain (low back pain)	G001: Pain in bones/joints	0.6
		G018: Pain in the lower back (waist)	1
		G019: Severe pain in the lower back (waist) after bending/lifting	0.8
		G020: Pain when sitting for a	0.6

The expert CF value for each symptom is different, but there are also similar values . The value for each symptom describes the influence of that symptom on bone disease. The greater the symptom value, it can be concluded that the symptom is the dominant symptom of disease in people with bone disease.

R1: IF G001 (1) AND G002 (0.6) AND G003 (1) AND G004 (0.8) AND G005 (0.8) AND G006 (0.8) THEN P001

Rule 1 is not executed because the rule is not fulfilled

R2: IF G001 (1) AND G007 (0.6) AND G008 (0.8) AND G009 (1) AND G010 (0.6) AND G011 (0.6) THEN P002

Rule 2 is not executed because the rule is not fulfilled

R3: IF G001(1) AND G012 (1) AND G013 (0.8) AND G014 (0.6) AND G015(0.6) AND G016 (0.6) AND G017 (0.8) THEN P003

CF symptom 1 = CF user * CF expert
= 0.6 * 0.6
= 0.36

CF symptom 2 = CF user * CF expert
= 0.8 * 1
= 0.8

CF symptom 3 = CF user * CF expert
= 0.4 * 0.8
= 0.32

CF symptom 4 = CF user * CF expert
= 0.4 * 0.6
= 0.24

CF symptom 5 = CF user * CF expert
= 0.6 * 0.6
= 0.36

CF symptom 6 = CF user * CF expert
= 0.8 * 0.6
= 0.48

CF symptom 7 = CF user * CF expert
= 0.8 * 0.8
= 0.64

R4: IF G001 (1) AND G018 (1) AND G019 (0.8) AND G020 (0.6) AND G021 (0.6) AND G022 (0.8) AND G023 (0.8) THEN P004

Rule 4 is not executed because the rule is not fulfilled

R5: IF G001 (1) AND G024 (0.8) AND G025 AND G026 (0.6) THEN P005

Rule 5 is not executed because the rule is not fulfilled

After all the symptoms contained in the rule are calculated, the CF combine equation is then carried out as follows:

CF combine 1 (CF 1 ,CF2) = CF symptom 1 + CF symptom 2
* (1 – CF symptom 1) = 0.36 + 0.8 * (1 – 0.36)
CF old = 0.7424

CF combine 2 (CF old ,CF3) = CF old + CF symptom 3
* (1 – CF old) = 0.7424 + 0.32 * (1 – 0.7424)
CF old = 0.824832

CF combine 3 (CF old ,CF4) = CF old + CF symptom 4
* (1 – CF old) = 0.824832 + 0.24 * (1 – 0.824832)
CF old = 0.18652449

CF combine 4 (CF old ,CF5) = CF old + CF symptom 5
* (1 – CF old) = 0.18652449 + 0.36 * (1–0.18652449)
CF old = 0.444584229

CF combine 5 (CF old ,CF6) = CF old + CF symptom 6
* (1 – CF old) = 0.444584229 + 0.48 * (1 – 0.444584229)
CF old = 0.71118379

CF combine 6 (CF old ,CF7) = CF old + CF symptom 7
* (1 – CF old) = 0.71118379 + 0.64 * (1 – 0.71118379)
CF old = 0.89602616

Confidence percentage = CF combine * 100%
= 0.89602616* 100%
= 89.60%

Thus, from tracing the rules and calculating the certainty factor, it can be said that the patient was identified as having Cervical Spondylosis (Pain in the Neck Bone) with a confidence level of 89.60%.

4. Conclusion _

After building a web-based expert system at Semen Padang Hospital, users/patients can diagnose bone diseases quickly and easily so that users/patients can minimize the time they have to come to the hospital. Bone disease diagnosis data can be stored properly and safely. After designing an expert system for diagnosing bone disease based on the symptoms felt by the patient, we can get a solution for initial treatment in treating bone disease. Helping patients diagnose bone disease so that it can be done correctly and accurately.

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