Journal of Intelligent Decision Support System (IDSS) 5 (1) (2022) 20-27

Published by: IOCSCIENCE

Journal of Intelligent Decision Support System (IDSS)

Journal homepage: www. idss.iocspublisher.org

Expert System to Diagnose Bonsai Plant Pests with Certainty Factor Method

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Article Info

Article history:

Received Dec 09, 2021
Revised Dec 20, 2021
Accepted Jan 11, 2022

Keywords:

Expert System;
Diseases and Pests;
Bonsai;
Certainty Factor

ABSTRACT

Bonsai ornamental plants are dwarf plants which are generally planted in shallow pots. The main element in bonsai is harmony between pots and plants, in addition to harmony between pots and plants there are also other elements such as trunk size, tree height, root distribution, twigs, and leaf size as well as diseases and pests that attack the bonsai plants need to be considered. The difficulty of the community in conducting consultations and the unavailability of funds and time, so that the community has never conducted consultations about diseases and pests that attack their bonsai plants to experts or plant extension workers from the relevant agencies. Therefore, it is necessary to take action to anticipate the increasing number of bonsai farmers who do not consult on diseases and pests of bonsai plants. This is due to the delay in the diagnosis of the disease. The unavailability of experts or plant extension workers who are close, the community does not have time to conduct consultations and requires money. An expert system is a computer-based system that uses knowledge, facts, and techniques and reasoning in solving problems that can usually only be solved by an expert in the field. The Certainty Factor method is efficient enough to be used in diagnosing the diseases and pests of the bonsai plant. This system can provide early diagnosis of diseases and pests on the bonsai plant based on the symptoms and intensity of the symptoms that are visible from the outside. Users only need to enter the Web to take the first step in solving bonsai plant diseases and pests and choose the symptoms of the disease they are experiencing without having to ask an expert directly. This system is made web-based with PHP programming language and MySQL database.

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1. Introduction

The art of Bonsai plants in Indonesia is one of the works of art by flower farmers and is quite well developed in Indonesia. This is because the State of Indonesia has good natural fertility and also a wealth of flora species because Indonesia is located in a tropical area. Indonesia is an archipelagic country and almost every island in Indonesia has a special type of flora, one of which is the Bonsai plant which is a characteristic of the island itself. These types of special flora in Indonesia can be used

as good Bonsai plant materials, where from these materials the artwork of Bonsai plants in Indonesia was born and developed well until now.

Bonsai plants are an artistic effort to dwarf plants as a representation of the beauty of the natural panorama which is full of various kinds of trees, both in shape, type, and color. In essence, the art of bonsai is imitating or making imitations of plant forms that exist in the wild whose growth languishes due to the ferocity of nature (Lembahmata, 2011). In bonsai farming, there are various kinds of diseases and pests that attack the bonsai plant, for example: aphids. In the spring aphids on Bonsai plants can become a real problem, especially on newly emerging young/mample leaves (Ipnuwati & Aditama, 2020). Many Bonsai plant farmers do not know the diseases and pests that have attacked their Bonsai plants, therefore we need a system that is able to diagnose diseases and pests on the Bonsai plant in the form of an expert system by applying the Certainty Factor method.

Previous research entitled Application of Forward Chaining and Certainty Factor Methods for Disease Diagnosis in Bonsai Plants where in this study diagnose bonsai plant diseases using two methods, namely forward chaining and certainty factor, the system was built to determine the symptoms that appear and the test results can provide a diagnosis diseases and pests on bonsai plants based on the symptoms given. However, in this study, the types of diseases and pests that were diagnosed only consisted of aphids, caterpillars, thrips, white hornworms, fungi, red shoots on stems and root tumors. While the types of diseases and pests that attack bonsai plants exceed the types of diseases and pests studied. Then in the study entitled "Expert System Determination of Style on Bonsai Plants Using the Certainty Factor Method", this study was designed to determine the style of bonsai that gives results in the form of pictures and names of bonsai plant styles (Dwilestari & Nurmiati, 2018). Then in a similar study entitled Expert System for Agribusiness Plant Diagnosis Using the Certainty Factor Method, in this study it was suggested that the certainty factor method is very suitable to be used to diagnose diseases in agribusiness plants because this method can help to overcome uncertainty in decision making and provide a percentage of diagnostic results. . From the results of testing this expert system, obtained the same results with manual calculations using the certainty factor method, so it is concluded that this expert system can be used to diagnose agribusiness plant diseases(Laely, 2020).

Expert systems are also commonly referred to in other words, namely knowledge based systems, a computer application intended to assist decision making or problem solving in specific fields (Rukun & Hayadi, 2018). An expert system is a part of artificial intelligence that is intended for diagnosing system failures and as a solution to problems(Setiawan, 2017). An Expert System is a knowledge-based program that provides expert quality solutions to problems in a specific domain. Expert System is a computer program that imitates thought processes and expert knowledge in solving a particular problem(Salisah, Lidya, & Defit, 2015).

This study aims to design and build an expert system for diagnosing Bonsai diseases and pests by applying the certainty factor method, and how to find out the results of the diagnosis and how to analyze the results of applying the certainty factor method to diagnose Bonsai plant diseases and pests.

2. Method

2.1 Cata Collection

The data in this study were carried out by literature studies and interviews(Makady, de Boer, Hillege, Klungel, & Goettsch, 2017).

a. Study of Literature
   Literature study is looking for theoretical references that are relevant to the cases or problems found according to the research title. These references are obtained from printed and electronic books, journals, research report articles, and searches on sites on the internet.
b. Interviews
   One method of data collection is by way of interviews, namely getting information by asking directly to respondents, the respondents referred to in this study are bonsai plant botanists and agricultural extension specialists, especially bonsai plant diseases to obtain data on types of bonsai plant diseases and their symptoms the symptoms. The respondent is Mr. Ir. Ariady Ribawa

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2.2 Data Anlysis

After collecting data and the data that has been collected, the next step is to analyze or process the data that has been previously collected using the certainty method with the aim that the problem formulation can be resolved so that the expert system for diagnosing diseases and pests in bonsai plants can be useful (Juliandi, Manurung, & Satriawan, 2018),(Situmorang, Muda, Doli, & Fadli, 2010)

TABLE 1
CHARACTERISTICS OF CERTAINTY FACTOR

No	Characteristics	Score
1	Reach	0 ≤ MB ≤ 1 0 ≤ MD ≤ 1 -1 ≤ CF ≤ 1
2	The Hypotesis Must Be True P(H|E)=1	MB = 1 MD = 0 CF = 1
3	The Hypotesys Must Be False P(H'|E) = 1	MB = 0 MD = 1 CF = -1
4	Lack of Facts P(H|E) = P(H)	MB = 0 MD = 0 CF = 0

Some of the rules for using the certainty factor method are as follows:

1) The rule for adding two certainty positive factors is
$$(CF_a\ CF_b)=CF_a+CF_b*(1-CF_a)$$
2) The rules for adding two negative certainty factors are:
$$(CF_c\ CF_d)=CF_c+CF_d+CF_c*CF_d$$
3) The rules for adding more complex positive and negative certainty factors are:
$$(CF_eCF_f)=\frac{CF_e+CF_f}{1-\min\{|CF_e|,|CF_n|\}}$$

These three rules provide an interval scale for the certainty factor. The examples of the application of the certainty factor rules mentioned above are as follows:

a. Examples for Positive Facts
   Strong Sugestive (CFa) : 0.7
   Sugestive (CFb) : 0.4
   Sugestive (CFb) : 0.4
   $CF_{Combine}$ (CFa CFb) 0.7 + 0.4 (1-0.7) = 0.82
b. Examples for Negative Facts
   Strong Suggestive (CFc) : -0.7
   Suggestive (CFd) : -0.4
   $CF_{Combine}$ (CFC CFd) = -0.7 + -0.4 + -0.7 * -0.4 = -0.82

3. Result and Discussion

In designing this expert system by taking sources from experts or doctors, books and journals. This web-based design is useful for diagnose bonsai plant pests with certainty factor method type of disease.

a. Type of Disease

TABLE 2
CHARACTERISTICS OF CERTAINTY FACTOR

Code	Disease	Treatment Solution	Group
P1	Aphids	Getting rid of diseased plants for a while, if not too severe can be overcome by spraying warm water once a week and sprayed with medicine. For example: water mixed with insecticidal soap which is safe and effective	Pest
P2	Caterpillar	Destroy the caterpillars, try to pull out weeds that grow around them so that pests don't come back or spray insecticides such as Curacron 100 ml and	Pest

Code	Disease	Treatment Solution	Group
		Dursban 200EC".	
P3	*Thrips*	Clean the plant with warm water and spray the appropriate medicine once a week for two weeks. The medicine: Counter Plus 100 Gram and Larban 550EC".	Pest
P4	White Whip	Get rid of the ants that are on the bonsai plant and clean with warm water, then given the appropriate medicine for white powder disease. For example: Phefoc HCS and METHA 400EC".	Pest
P5	Red Whip on the Stem	The bonsai tree is brushed with a toothbrush and sprayed with insecticide. For example: Ointment Kambiun Bonsai Fungicide, Lime Sulfur 300 ml and Ointment Kambiun Healthy Liquid 100 ml.	Pest
P6	*Aphis*	Control of this pest is very easy, you just need to spray it with high pressure water so it will fall and die, or you can also use a mild insecticide such as Curacron 500EC, Decis 2.5 EC, and Confidor 200 SL.	Pest
P7	Shell or Shield Lice	This pest control is recommended by selective use of synthetic pesticides. In addition, the application of plant-based pesticides (non-synthetic) can also be carried out in the form of extracts of keben seeds, Lamda Sihalotrin and Triazofos 0.5%.	Pest
P8	Snail	Use special toxic pellets for snails or by fishing for their arrival by placing cassava or sticky rice on a bonsai tree pot at night, then the next morning the snails around the tapai are killed, or using molluscicides with active ingredients fentin acetatefentin acetate and or metaldehyde (metadehyde).	Pest
P9	Mold	Remove the damaged plant parts, then spray with warm water or treat with insecticides. For example: Dithane M45 200 Grams.	Disease
P10	Root Tumor	The solution is to replace the old soil with new soil, or apply a fungicide to the trunk of the bonsai tree. For example: Calixin, Fylomax or bordo porridge by using a brush up to 30 cm upwards to the bottom of the affected part of the root tumor, and if the attack is advanced, then exfoliate the rotten root bark and then lubricate it with Calixin RM to taste.	Disease
P11	Powdery Mildew	The treatment solution is to use a wettable sulfur-based fungicide (3G/L) hexaconazole, tripumizole, microbutanil (total 2 ml/L).	Disease

b. Symptoms

TABLE 3
SYMPTOMS

Code	Symptoms
G001	Dried or curled leaves
G002	Brown leaves
G003	The leaves and stems are weak
G004	No new leaves grow
G005	The leaves have holes
G006	There is caterpillar droppings on the surface of the leaves or stems
G007	The buds fail to become flowers and fall
G008	The spots on the leaves then blister and fall off
G009	Upper and lower leaf surfaces turn black, Brown leaves
G010	Surrounded by ants, then there are fly eggs on the underside of the leaves
G011	There is a beast in the bark of the stem
G012	The tops of the leaves become wrinkled, curled and curled
G013	In heavy attacks it causes stunted plant growth, wilts and even dies
G014	Plants do not grow normally, causing stunted plants and the leaves become a mosaic
G015	In conditions of severe attack, this pest colony can abort the leaves of the bonsai plant as a whole
G016	Bonsai plant leaves wither
G017	In the next attack the leaves and flowers fall without remaining
G018	Attacking the stems, twigs or leaves of newly seeded bonsai
G019	The green color of the affected part will turn yellow
G020	Indirect damage is the emergence of sooty mold (capnodium) on the surface of plants that are attacked by shell lice
G021	These pests often leave irregular and often large holes in the leaves
G022	The presence of silver-colored slime spots found on the leaves of bonsai plants and the surface of the soil in pots
G023	Young bonsai plant seeds are very liked and eaten by these snail pests
G024	Withered Plant
G025	Crown fall
G026	Curly leaf shoots
G027	Stalks and leaves turn yellow and tear rot
G028	Stems and roots rot

Code	Symptoms
G029	If watered, it doesn't run out quickly
G030	New leaves don't grow and the shoots wilt quickly
G031	At first, yellow spots appear on the upper side of the leaves
G032	At a later stage, the white powdery layer turns gray and covers the entire surface of the leaves and stems of the bonsai
G033	As the disease progresses, the infected part shrivels up and the leaves fall off and die

c. Disease Probability Score

TABLE 4
INTERPRETATION OF CERTAINTY FACTOR WEIGHT VALUE MB

Certainty Term	MB Value
Unknow	0
Maybe Yes	0.40 – 0.74
Probably Yes	0.75 – 0.89
Almost Certainty Yes	0.90 – 0.99
Definetely Yes	1.0

TABLE 5
INTERPRETATION OF CERTAINTY FACTOR WEIGHT VALUE MB

Certainty Term	MD Value
Definetely Not	0 – 0.02
Almost Certainty Not	0.03 – 0.05
Probably Not	0.06 – 0.08
Maybe Not	0.09 – 0.10

d. Knowledge Base

TABLE 6
RULE S

	Rules
Rule 1	**IF** G001 **AND** G002 **AND** G003 **AND THEN** P1
Rule 2	**IF** G005 **AND** G006 **THEN** P2
Rule 3	**IF** G007 **AND** G008 **THEN** P3
Rule 4	**IF** G009 **AND** G010 **THEN** P4
Rule 5	**IF** G011 **THEN** P5
Rule 6	**IF** G012 **AND** G013 **AND** G014 **AND** G015 **THEN** P6
Rule 7	**IF** G016 **AND** G017 **AND** G018 **AND** G019 **AND** G020 **THEN** P7
Rule 8	**IF** G021 **AND** G022 **AND** G023 **THEN** P8
Rule 9	**IF** G024 **AND** G025 **AND** G026 **AND** G027 **AND** G028 **THEN** P9
Rule 10	**IF** G029 **AND** G030 **THEN** P10
Rule 11	**IF** G031 **AND** G032 **AND** G033 **THEN** P11

e. Determining MB and MD Values

TABLE 7
MB AND MD PROBABILITY SCORE FOR EACH SYMPTOM

Code	Symptoms	MB	MD	CF=MB-MD
G001	Dried or curled leaves	1.00	0.00	1.00
G002	Brown leaves	0.93	0.06	0.87
G003	The leaves and stems are weak	0.90	0.04	0.86
G004	No new leaves grow	0.70	0.05	0.65
G005	The leaves have holes	1.00	0.00	1.00
G006	There is caterpillar droppings on the surface of the leaves or stems	0.93	0.05	0.88
G007	The buds fail to become flowers and fall	1.00	0.05	0.95
G008	The spots on the leaves then blister and fall off	0.90	0.02	0.88
G009	Upper and lower leaf surfaces turn black, Brown leaves	1.00	0.00	1.00
G010	Surrounded by ants, then there are fly eggs on the underside of the leaves	0.95	0.04	0.91

Code	Symptoms	MB	MD	CF=MB-MD
G011	There is a beast in the bark of the stem	1.00	0.06	0.94
G012	The tops of the leaves become wrinkled, curled and curled	0.95	0.05	0.90
G013	In heavy attacks it causes stunted plant growth, wilts and even dies	0.76	0.06	0.70
G014	Plants do not grow normally, causing stunted plants and the leaves become a mosaic	0.94	0.05	0.89
G015	In conditions of severe attack, this pest colony can abort the leaves of the bonsai plant as a whole	0.65	0.06	0.59
G016	Bonsai plant leaves wither	1.00	0.00	1.00
G017	In the next attack the leaves and flowers fall without remaining	0.94	0.02	0.92
G018	Attacking the stems, twigs or leaves of newly seeded bonsai	0.75	0.06	0.69
G019	The green color of the affected part will turn yellow	0.92	0.03	0.89
G020	Indirect damage is the emergence of sooty mold (capnodium) on the surface of plants that are attacked by shell lice	0.70	0.04	0.66
G021	These pests often leave irregular and often large holes in the leaves	0.95	0.03	0.92
G022	The presence of silver-colored slime spots found on the leaves of bonsai plants and the surface of the soil in pots	0.84	0.05	0.79
G023	Young bonsai plant seeds are very liked and eaten by these snail pests	0.93	0.02	0.91
G024	Withered Plant	0.90	0.02	0.88
G025	Crown fall	0.80	0.03	0.77
G026	Curly leaf shoots	0.60	0.05	0.55
G027	Stalks and leaves turn yellow and tear rot	0.89	0.04	0.85
G028	Stems and roots rot	0.95	0.02	0.93
G029	If watered, it doesn't run out quickly	1.00	0.02	0.98
G030	New leaves don't grow and the shoots wilt quickly	0.87	0.05	0.82
G031	At first, yellow spots appear on the upper side of the leaves	1.00	0.00	1.00
G032	At a later stage, the white powdery layer turns gray and covers the entire surface of the leaves and stems of the bonsai	0.97	0.04	0.93
G033	As the disease progresses, the infected part shrivels up and the leaves fall off and die	0.83	0.05	0.78

f. Case Study Examples

TABLE 8
MB AND MD PROBABILITY SCORE FOR EACH SYMPTOM

Code	Symptom	User Answer	Score
G001	Dried or curled leaves	Definetely Yes	1.0
G002	Brown leaves	Definetely Yes	1.0
G003	The leaves and stems are weak	Probably Yes	0.8
G006	There is caterpillar droppings on the surface of the leaves or stems	Maybe Yes	0.6
G007	The buds fail to become flowers and fall	Almost Certainty Yes	0.9
G008	The spots on the leaves then blister and fall off	Definetely Yes	1.0
G011	There is a beast in the bark of the stem	Maybe Yes	0.6

If viewed from several disease symptoms that have been selected by the user, the symptoms of the disease can be classified based on the type of disease below:

1) G001, G002 , and G003 belong to diseases and pests: P1
2) G006, which belongs to the types of diseases and pests: P2
3) G007 and G008, which belong to the types of diseases and pests: P3
4) G011, which belongs to the types of diseases and pests: P5

The next step is to calculate the expert CF (Certainty Factor) value for each disease symptom selected by the user:

a. Diseases and Pests : P1
   1) G001 : Dried or curled leaves
      CF(H,E) = MB – MD = 1.0 – 0.0 = 1
   2) G002 : Browns Leaves
      CF(H,E) = MB – MD = 0.93 – 0.06 = 0.87
   3) G003 : The Leaves and Stems are weak
      CF(H,E) = MB – MD = 0.90 – 0.04 = 0.86

After knowing the expert CF value for each symptom, the CF value for each symptom is calculated by multiplying the expert CF with the User CF:

   1) G001 : Dried or curled leaves
      $CF(H,e) = CF_{user} * CF_{pakar} = 1.0 * 1 = 1$
   2) G002 : Browns Leaves
      $CF(H,e) = CF_{user} * CF_{pakar} = 1.0 * 0.87 = 0.87$
   3) G003 : The Leaves and Stems are Weak
      $CF(H,e) = CF_{user} * CF_{pakar} = 0.8 * 0.86 = 0.69$

Then combine the CF values of each symptom:

$CF_{combine1}\ CF(H,E)_{1,2} = CF_{G001} + CFG_{002} * (1-CF_{G001}) = 1 + 0.87 * (1-1) =$ **1**

$CF_{combine2}\ CF(H,E)_{old,3} = CF_{old} + CF_{G003} * (1-CF_{old}) = 1 + 0.69 * (1-1) =$ **1**

So, when used as a percentage, then:
Disease: P1 = 1 * 100 = 100%. Thus, from the three symptoms selected by the user from the disease: Aphids on Bonsai plants, the conclusion based on the calculation of the diagnosis experienced is P1 with a confidence level of 100%.

b. Disease and Pests : P2
   1) G006 : There is Caterpillar droppings on the surface of the leaves or stems
      CF(H,E) = MB – MD = 0.93 – 0.05 = 0.88
      Since the type of symptom selected by the user is only one type in P2 disease, then after knowing the expert CF value of the symptom selected by the user the CF value of the symptom is calculated by multiplying the expert CF by the User CF:
   2) G006 : There is Caterpillar droppings on the surface of the leaves or stems
      $CF(H,e) = CF_{user} * CF_{pakar} = 0.6 * 0.88 = 0.53$
      If used as a percentage then:
      Disease P2 = 0.53 * 100 = 53%
      Since only one symptom was selected for P2 disease, the conclusion based on the calculation of the diagnosis experienced by bonsai plants was P2 with a confidence level of 53%.

c. Disease and Pests : P3
   1) G007 : The buds fail to become flowers and fall
      CF(H,E) = MB – MD = 1 – 0.05 = 0.94
   2) G008 : The spots on the leaves then blister and fall off
      CF(H,E) = MB – MD = 0.9 – 0.02 = 0.88

   Since the symptom selected by the user is more than one symptom, after knowing the expert CF value for each symptom, the CF value for each symptom is calculated by multiplying CF_{pakar} with CF_{user} :

   1) G007 : The buds fail to become flowers and fall
      CF(H,e) = CFuser * CFpakar = 0.9 * 0.94 = 0.85
      G008 : The spots on the leaves then blister and fall off
   2) CF(H,e) = CFuser * CFpakar = 1.0 * 0.88 = 0.88
      Then combine the CF values of each symptom:
   3) CFcombine1 CF(H,E)1,2 = CFG007 + CFG008 * (1-CFG007) = 0.85 + 0.88 * (1-0.85) = 0.98

d. So, when used as a percentage, then:
   Diseases and pests: P3 = 0.98 * 100 = 98%.

Thus, from the two symptoms selected by the user from the disease: P3 on Bonsai plants, the conclusion based on the calculation of the diagnosis experienced by bonsai plants is P3 with a confidence level of 98%

4. Conclusion

An expert system using the certainty factor method can be used to determine the value of the confidence factor regarding the attack of diseases and pests on bonsai plants based on the symptoms of diseases and pests that have been determined. By building this expert system application, it can produce good diagnostic results, as evidenced by the results of the application of the certainty factor method in accordance with the certainty factor design and the rule base that has been built. So that the application can provide information on the results of the analysis and the results of the calculation of the certainty factor method with an accuracy of up to 90% compared to the results of the analysis of expert examinations or bonsai plant extensionists.

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