Journal of Theoretical and Applied Information Technology
15th May 2023. Vol.101. No 9

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

ANALYSIS OF BEST FIRST SEARCH AND FORWARD CHAINING ALGORITHM ON DIAGNOSIS SYSTEM OF BROILER CHICKEN DISEASES

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ABSTRACT

Broiler chicken farming is among the most profitable business in Indonesia. Gotland Simatupang Farm is one of the broiler farms in Indonesia. The mortality rate of chickens on this farm is still relatively high. In the last three months, the average mortality proportion was 109.30% whereas in January the total of chicken deaths was 43 chickens and in March the total chicken deaths soared to 90 chickens. After observing the death of chickens, it was caused by several factors. The main cause was disease. Based on the results of discussions with the management of the farm, it was found that there was a lack of veterinarians on the farm. Therefore, a system was built in this study that can help farmers diagnose broiler disease using the Best First Search (BFS) method and the Forward Chaining method. The types of diseases that can be diagnosed in this system only consist of 5 diseases, namely Newcastle Disease, Infectious Bursal Disease, Pullorum, Avian Influenza, and Snot. The system output is the dis disease-affected broiler chickens. System testing is done by comparing the test results with existing sample data. In testing on 20 samples, the actual score % of the accuracy of diagnostic results in the system using the Best First Search method by 70% while using the Forward Chaining method by 90%. Therefore, it can be said that the Forward Chaining method is more accurate than Best First Search.

Keywords: *Best First Search, Forward Chaining, Broiler, Disease*

1. INTRODUCTION

Poultry businesses are one of the fastest-growing businesses due to the demand for poultry products. Broiler chicken farming is among the most profitable poultry business in Indonesia.

Gotland Simatupang Farm is one of the broiler farms in Indonesia, located in Sibolga, Sumatera Utara. This farm can harvest at least about 11,000 chickens every month, but the mortality rate of chickens on this farm is also still relatively high. In the last three months, the average mortality proportion was 109.30%, wherein 43 chickens were dead in January and soared to 90 chickens in March. After observing the causes of the dead chickens, it was caused by several factors. The main cause of death was disease.

Based on the results of discussions with the management of the farm, it was found that there was a lack of veterinarians on the farm. This makes the situation worse because the farm manager can't cure the chicken due to a lack of knowledge which hurt the death rate of chickens every month. So we need an expert system that can be used to diagnose chicken diseases as well as a system that provides additional information related to disease prevention and control. Therefore, a system was built in this study to help farmers in diagnosing broiler chicken diseases using the Best First Search (BFS) method and the Forward Chaining method. The scope of study in this research is the types of diseases that can be diagnosed in this system only consist of 5 diseases, namely Newcastle Disease, Infectious Bursal Disease, Pullorum, Avian Influenza, and Snot. The system is built using Android Studio with Java language, and Google Firebase

Expert systems are computer-based systems that use knowledge, a special knowledge owned by an expert to solve a particular problem. This system is used to duplicate or simulate expert-owned skills to solve problems [1]. Efforts to overcome the problems, namely by using an expert system with Best First Search (BFS) and Forward Chaining method. This research will compare the two methods to find the more efficient method.

Forward chaining is a method that is based on data or facts leading to a conclusion. The forward chaining operation starts by inputting the facts into working memory, then matching the fact with known rules [2]. Best First Search is a method that generates a node from the previous node. Best First Search selects a new node that has the lowest cost among all leaf nodes that have ever been generated. The Best First Search evaluation function can be an approximate cost of a node towards the goal or a combination of the actual cost and the estimated cost [3].

In this study, the authors will compare the Best First Search (BFS) method and the Forward Chaining method to determine the more accurate method for the diagnosis system of broiler chicken diseases.

The formulation of the problem in this study is the unavailability of veterinarians at Gotland Simatupang Farm, it hurts the death rate of chickens every month. An expert system that can be used to diagnose chicken diseases based on the symptoms that appear and provide information related to the prevention and control of the disease.

2. THEORETICAL FRAMEWORK

2.1 Expert System

Expert system is a branch of Artificial Intelligence (AI), which was developed and popular in 1960. One of the earliest popular definitions of AI was and still is "making computers think like people", as evidenced by the large number of science fiction movies that promote this view [5]

In the 1960s, expert systems were developed as research tools as a special type of artificial intelligence to successfully deal with complex problems in narrow domains such as medical disease diagnosis. The classic problem of building a general-purpose artificial intelligence program that can solve any problem has been too difficult without specific knowledge of the problem domain, e.g. medical disease diagnosis. Expert systems have greatly increased in popularity since their commercial introduction in the early 1980s. Today, expert systems are used in many fields such as science, manufacturing, business, engineering, and other fields that exist in a well-defined problem domain.

Expert systems are a very successful application of artificial intelligence technology. Many hybrid approaches exist to combine expert systems with other techniques including genetic algorithms and artificial neural networks. The common term for a system that uses artificial intelligence is an intelligent system or automated system.

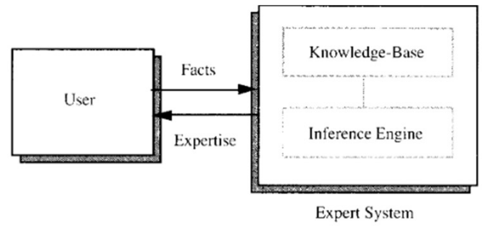

Figure 1: Basic Function of an Expert System

Figure 1 illustrates the basic concept of a knowledge-based expert system. The user supplies facts or other information to the expert system and receives expert advice or expertise in response. Internally, the expert system consists of two main components. The knowledge base contains the knowledge from which the inference engine concluded. The conclusions are the expert system's responses to the user's queries for expertise.

Expert systems have been combined with databases for human-like pattern automated decision systems to yield knowledge discovery through data mining and consequently produce an intelligent database. Another exhilarating area of AI has to do with artificial discovery systems. These are computer programs that can discover knowledge in certain problem domains [6].

AI expert system is a program with knowledge-based obtained from expert experience, knowledge, and expertise in solving problems in a specific area. AI Expert System is also known as an inference-powered engine that has the reasoning or the tracking of something facts and rules in the knowledge base.

Expert systems make extensive use of specialized knowledge to solve problems at the level of human experts. An expert person who has expertise in a certain area. The expert has knowledge or special skills that are not known or available to most people. An expert can solve problems that most people cannot solve at all or solve them much more efficiently but not necessarily as inexpensively. When expert systems were first developed they contained expert knowledge exclusively. Nevertheless, the term expert system is often applied today to any system that uses expert system technology. That technology may include special expert system languages, programs, and hardware designed to aid in developing and executing expert systems [7].

With the help of an expert system of people who are not experts and experts can answer questions, solve problems, and make decisions that are usually done

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

by experts. The knowledge of an expert system may be represented in several ways. One of the most common methods to represent knowledge is in the case of a rule type (rule) IF-THEN. Although the way above is very simple, many things mean building an expert system by expressing expert knowledge in the form of the above rules.

Expert systems have several beneficial features:

1. Increased availability.
   Expertise is available on any suitable computer hardware. An expert system is the mass production of expertise.
2. Reduced cost.
   The cost of providing expertise per user is greatly lowered.
3. Reduced risk.
   Expert systems can be used in environments that might be hazardous for a human.
4. Permanence and preservation.
   The expertise is permanent. Unlike human experts who may retire, quit, or die. The expert system's knowledge will last indefinitely.
5. Multiple expertise.
   The knowledge of multiple experts can be made available to work simultaneously and continuously on a problem at any time of day or night. The level of expertise combined from several experts may exceed that of a single human expert.
6. Increased reliability and high quality.
   Expert systems increase confidence that the correct decision was made by providing a second opinion to a human expert or a tie-breaker in disagreements among multiple human experts. The expert system should always agree with the expert; unless a mistake was made by the expert, which may happen if the human expert is tired or under stress.
7. Explanation.
   The expert system can explain in detail the reasoning that led to a conclusion. A human may be too tired, unwilling, or unable to do this all the time. This increases the confidence that the correct decision is made.
8. Fast response.
   A fast or real-time response may be necessary for some applications. Depending on the software and hardware used, an expert system may respond faster and be more available than a human expert. Some emergencies may require responses faster than a human; in this case, a real-time expert system is a good choice.
9. Steady, unemotional, and complete response at all times.
   This may be very important in real-time and emergencies when a human expert may not operate at peak efficiency because of stress or fatigue.
10. Intelligent tutor.
    The expert system may act as an intelligent tutor by letting the student-run sample programs and explaining the system's reasoning.
11. Intelligent database.
    Expert systems can be used to access a database intelligently. Data mining is an example.

Some disadvantages exist in the expert system as follows:
1. Difficult in developing the system due to limited expertise and expert availability.
2. Limited to the domain of expertise.
3. Designed to be developed gradually.
4. Can provide reasoning for uncertain data.
5. Based on certain rules.
6. The system can enable the rule in the appropriate direction which is guided by a dialogue with the user.
7. Knowledge and inference mechanisms are separated.
8. Can bring up the series of reasons it provides in understandable ways.
9. The output is recommended.

2.2 Best First Search Method

Best First Search is a combination of Breadth First Search and Depth First Search algorithms. It selects the path which appears best now, uses a heuristic function, and searches. Best First Search expands the node that is closest to the goal node and lowers the value of the estimated distance between a node and the objective node, the closer is the node from the goal [8].

The best first search is a priority-based queue to handle the incoming node problems. The aftermath can be determined by keeping in mind the starting points. If we face the problems, two anomalies heave in sight are the bug linked with the depth-first search and breadth-first search. Every problem is particularly concerning the situation we are using. The best first search employs the strengths of all the problems. The major reason for using the BFS is the complexity problems both own, hence BFS method

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

turns up to solve the problem, leading to a better result. The approach is heuristic-based and hence more efficient in leading to a proper and reliable result. Suppose a graph contains multiple nodes such as a → b → c → d→ e → f and so on creating a chain and now suppose the heuristic value of the chain is different for different values.

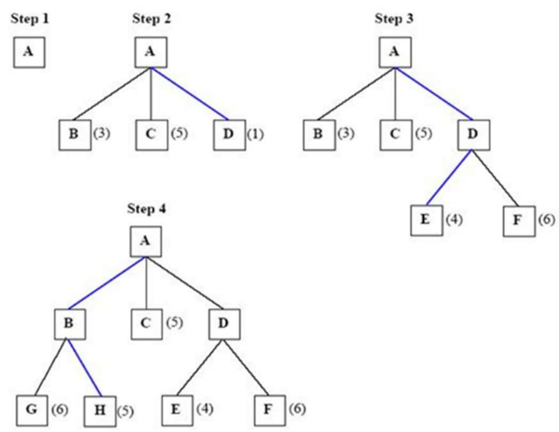

Figure 2: Best First Search in a Graph

The f (n) signifies the heuristic value of the node and contains information such as the distance, it assumes from the node and its respective node weightiness and averages. Now in the best first search module, it is to understand which node is to be used. As A is the primary starting node in a binary tree its outcomes are B, C, and D. According to the heuristic values of these nodes, D is having the inferior value, therefore node D is chosen. It can be seen that node A has three outcomes and out of them, the minimum is node D has the heuristic value of one hence it will be chosen. It has further two nodes that we need to manage to solve the forthcoming problem, it needs to see how to deal with the thing. As out of the three nodes we are picking one node thus the probability will come out to be one-third. Then furthermore D has two more nodes E and F. Further, the node with lower heuristics will be picked. Now the comparison will be made with the present nodes as well as the previous nodes. It can be seen that node B has the littlest of them all, therefore it is chosen compared to others. Thereupon the main advantage is that the chosen node is based on particular values rather than path. This is the clearest advantage that it carries over Breadth First Search and Depth First Search. Thus the advantages are carried over to others smoothly [9].

2.3 Forward Chaining Method

The forward Chaining method is data-driven since the information starts from existent information and leads to the conclusion [10]. The forward chaining method is also known as the forward tracking method. Advanced rules of reasoning are tested one by one in a certain order. The sequence can be either a sequence of rules of instantiation into base rules or another sequence decisive by the user. Every single time a rule is tried, the expert system will assess whether the condition is true or false. If the condition is true, then the rule is kept then the next rule is tested. Contrariwise, if the condition is false, it is not stowed and the next rule is tested. This process would be repeated until all of the rules were tested with a variety of conditions. Advanced reasoning work with problems that started with the recording of the initial information and the final settlement to be achieved, then the whole process will be carried out consecutively.

2.4 Chicken Diseases

2.4.1 Newcastle Disease

Newcastle disease is a global problem. From January 2013 through December 2016, 71 of the 181 OIE member countries reported ND in domestic poultry. The disease is particularly problematic for poultry producers in countries in the Middle East, Africa, and Asia. Confusing the situation, some countries with endemic NDV still use mesogenic NDV strains as live vaccines that are defined as virulent due to their cleavage sites and high ICPI values.

The first documented outbreaks of ND occurred in 1926 in Java, Indonesia, and Newcastle upon Tyne, England. Even though Doyle initially suggested "Newcastle disease" as a temporary moniker for outbreaks caused by these viruses, over time it has become the *de facto* designation. The synonym, avian paramyxovirus type 1 (APMV-1), was suggested by Tumova years later to distinguish NDV from other serotypes of avian paramyxoviruses.

Newcastle disease is defined by the OIE as an infection of birds caused by a virus of avian paramyxovirus serotype 1 (APMV-1) that meets one of the following criteria for virulence:

1. The virus has an intracerebral pathogenicity index (ICPI) in day-old chicks (Gallus gallus) of 0.7 or greater; or
2. Multiple basic amino acids have been demonstrated in the virus (either directly or by deduction) at the C-terminus of the F2 protein and phenylalanine at residue 117, which is the N-terminus of the F1 protein. The term multiple basic amino acids refer to at least 3 arginine or lysine residues between residues 113 and 116.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Failure to demonstrate the characteristic pattern of amino acid residues as described above would require characterization of the isolated virus by an ICPI test.

Newcastle disease also has been referred to as exotic Newcastle disease (END), pseudo-fowl pest, pseudopod a typical Geflugelpest, pseudo-poultry plague, avian pest, avian distemper, Ranikhet disease, Newcastle disease, and Korean fowl plague, and avian pneumoencephalitis. In addition, variant APMV-1 isolates from pigeons are often referred to as pigeon paramyxovirus type 1 (PPMV-1).

Horizontal transmission of NDV has been documented many times. Infected birds shed NDV in oropharyngeal secretions and fecal matter. Susceptible birds may become infected by inhaling contaminated dust or aerosolized virus, or by ingesting such material. Infection by inhaling aerosolized virus is illustrated by the success of applying live NDV vaccines using nebulizers. The ingestion of contaminated feces or contaminated carcasses can cause infection in chickens and raptors. Applying vaccines to chickens via drinking water is another demonstration of oral infection. While immunized chickens may shed vNDV for 6–9 days after challenge or until they succumb, unvaccinated wild or captive exotic birds like parrots, cormorants, and pigeons may have prolonged shedding of vNDV, usually in feces, without clinical signs.

The incubation period for natural exposures to NDV varies between 2 and 15 days, averaging around 5–6 days, but may take 3–4 weeks in some circumstances. Aerosol transmission may have a shorter incubation time than an infection started through ingestion of the virus.

Neither the clinical signs nor the gross lesions are pathognomonic for ND. Not vaccinated chickens infected with virulent viscerotropic isolates become listless and depressed two days after infection, ending with 100% mortality by the third or fourth day. With an oculonasal route of infection, bilateral conjunctivitis with some facial swelling may be present. Often clear mucus will pour from the mouths of infected birds if their heads droop toward the ground, leaving the bird gasping for air as it tries to clear the oral cavity of fluid. This fluid may appear to be nasal secretions but is more likely crop fluid related to stasis of the gastrointestinal tract, and it pours from the mouth when the crop is compressed as the bird is handled. The feces of infected birds may be green and watery. The comb may become blue as the bird becomes cyanotic, but hemorrhages are only seen with some isolates [11].

2.4.2 Infectious Bursal Disease

Infectious bursal disease (IBD) is an acute, highly contagious viral infection of young chickens that have lymphoid tissue, especially the cloacal bursa (bursa of Fabricius) as its primary target. IBD was first described in 1962 and was referred to as “avian nephrosis” because of the extreme kidney damage found in birds that succumbed to infection.

Since the first outbreaks occurred in the area of Infectious Bursal Disease, Delaware, “Infectious Bursal Disease” is still a frequently used synonym for this disease. The economic importance of this disease is manifested in two ways. First, some virus strains may cause up to 60% mortality in chickens 3 weeks of age and older. The second, and more important, manifestation is severe, prolonged immunosuppression of chickens when infected at an early age. Sequelae that have been associated with immunosuppression induced by the virus include gangrenous dermatitis, inclusion body hepatitis-anemia syndrome, *Escherichia coli* infections, and vaccination failures.

Protection of young chicks from early infection is paramount. This is usually accomplished by a combination of the transfer of maternal antibodies, and active immunization of the newly hatched chick. The virus does not affect humans and has no public health significance.

The infectious bursal disease is highly contagious, and the virus is persistent in the environment of a poultry house. Houses from which infected birds were removed were still infective for other birds at 54 and 122 days later. They also demonstrated that water, feed, and droppings taken from infected pens were infectious after 52 days.

Common symptoms seen in chickens with infectious bursal disease are as follows: lethargy, sleep, dirty in the anal area, diarrhea with a whitish color, bending body position, and the beak hanging down during sleep.

2.4.3 Pullorum Disease

Pullorum disease of chickens is a bacterial infection caused by *Salmonella enterica* subspecies *enterica serovar Pullorum* in short *Salmonella pullorum* [20]. *Salmonella* infections in poultry flocks can cause acute and chronic clinical diseases but have received greater international attention in recent years because of their role in foodborne outbreaks of

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

human illness. Contaminated poultry meat and eggs are among the most frequently implicated food vehicles of salmonellae. As a consequence of both public health and flock health concerns, *Salmonella* infections cause economically significant losses for poultry producers in many nations and absorb large investments of government and private resources for testing and control efforts. Accordingly, the present edition of this chapter focuses on these food-transmissible "paratyphoid" salmonellae.

Pullorum disease is usually symptomatic only in young birds, but occasional outbreaks are reported in older animals. The number of birds infected (morbidity) and the number of birds that die (mortality) vary by age, the strain of the bird, management, nutritional status, route and dose of exposure, and other disease stresses like concurrent infections in the flock. Pullorum disease in chicks can have up to 100 percent mortality, with the highest losses, particularly at two to three weeks of age. Among chickens, lighter breeds such as leghorns are more resistant to pullorum disease than heavier breeds. Mortality is usually highest in chicks and poults, the morbidity rate is often significantly higher than the mortality rate, and some birds recover.

Salmonella can be spread by vertical transmission, via an egg-associated (trans-ovarian) transmission to progeny and horizontal transmission to other hosts including humans as well as various sources, including parent birds, feedstuffs, rodents, wild birds, and other vehicles.

Clinical signs in chicks and poults include anorexia, diarrhea, dehydration, depression, huddling, ruffled feathers, weakness, pasting of the vent feathers, excessive numbers of dead in shell chicks, and the highest mortality after hatching occurs in 2-3 weeks of age. Feed and water intake were dramatically reduced in the infected group. In mature birds, Pullorum disease is less severe or in apparent but laying hens are characterized by decreased egg production, poor hatchability, and fertility. Trans-ovarian infection results in an infection of the egg and hatched chicks or poults, which is one of the most important causes of embryonic death and chick mortality in poultry farms.

2.4.4 Avian Influenza

Avian influenza is a broad term used to describe any infection or disease in birds caused by a Type an influenza virus. The term "avian influenza viruses" is used to describe influenza a virus found customarily in birds. Wild waterfowl and other aquatic birds are the primordial reservoirs of all influenza viral genes. The appellation "bird flu" is used as a simplified alternative to AI by the media to describe infections in poultry, humans, and other mammals with Type influenza viruses derived from birds.

The highly lethal systemic disease caused by AI viruses is referred to as "highly pathogenic avian influenza" or "high pathogenicity avian influenza" (HPAI). Before 1981, HPAI was known by various names including fowl plague (most common), fowl pest, pest aviaries, Geflügelpest, typhus exudations gallinarum, Brunswick bird plague, Brunswick disease, fowl disease, and fowl or bird grippe. Milder forms of AI have been termed low pathogenic, non-highly pathogenic, and low pathogenicity AI (LPAI).

Avian influenza virus is shed from the nares, mouth, conjunctiva, and cloaca of infected birds into the environment because of virus replication in the respiratory, intestinal, renal, and/or reproductive organs. HPAI viruses can also be detected in the epidermis including feathers, feather follicles, and glands such as the preen gland resulting in environmental contamination. In intranasal inoculated 3–4-week-old chickens, peak levels of HPAI virus recovery have been greatest from the oropharynx and peak levels from the cloaca have been lower. With HPAI viruses, high virus levels in tissues of infected birds make consumption of carcasses through predation or cannibalism another source of virus transmission to susceptible birds.

The incubation periods for the various diseases caused by these viruses range from as short as a few hours in intravenously inoculated birds to 3 days in naturally infected individual birds and up to 14 days in a flock. The incubation period is dependent on the dose of the virus, the route of exposure, the species exposed, and the ability to detect clinical signs.

Clinical signs of AI are extremely variable and depend on other factors including host species, age, sex, concurrent infections, acquired immunity, and environmental factors.

The most frequent signs represent infection of the respiratory tract and include mild to severe respiratory signs such as coughing, sneezing, rales, rattles, and excessive lacrimation. In layers and breeders, hens may exhibit increased broodiness and decreased egg production, which in some cases may never recover back to reinfection levels. In addition, domestic poultry will exhibit generalized clinical signs including huddling, ruffled feathers, listlessness, decreased activity, lethargy, decreased feed and water consumption, and occasionally diarrhea. Emaciation has been reported but is infrequent because AI is an acute, not a chronic disease. Secondary infections can exacerbate clinical disease and increase mortalities. In ratites, low pathogenicity AI viruses produced similar respiratory signs to those in gallinaceous poultry and some cases green diarrhea or green “urine”.

HPAI viruses can cause clinical diseases including neurological signs, depression, anorexia, and sudden death. Clinical manifestations vary depending on the extent of damage to specific organs and tissues (i.e., not all clinical signs are present in every bird). In most cases in chickens and turkeys, the disease is fulminating with some birds being found dead and observation of any clinical signs. If the disease is less fulminating and birds survive for 3–7 days, individual birds may exhibit nervous disorders such as tremors of the head and neck, inability to stand, torticollis, opisthosomas, and other unusual positions of head and appendages. The poultry houses may be unusually quiet because of decreased activity and a reduction in the normal vocalizations of the birds. Listlessness is common as are significant declines in feed and water consumption. Precipitous drops in egg production occur in breeders and layers with typical declines including total cessation of egg production within six days. Respiratory signs are less prominent than with LPAI viruses but can include rales, sneezing, and coughing. Other poultry has similar clinical signs but may live longer and have evidence of neurologic disorders such as paresis, paralysis, vestibular degradation (torticollis and nystagmus), and general behavior aberrations [12].

2.4.5 Infectious Coryza (Snot)

Infectious coryza is one of the respiratory diseases in chickens caused by *Avibacterium paragallinarum*, an organism that typically requires nicotinamide dinucleotide (NAD) for in vitro growth. Snot cases can be acute or chronic and diagnosed based on rapid disease-spreading clinical symptoms, and pathological changes.

The clinical manifestation of infectious coryza has been described in the early literature as roup, contagious or infectious catarrh, cold, and uncomplicated coryza. The disease was named infectious coryza because it was infectious and primarily affected the nasal passages. No specific syndrome name has been allocated to the disease conditions associated with *Av. gallinarum* and *Av. endocarditis*.

The greatest economic losses associated with infectious coryza result not only from poor growth performance in growing birds and marked reduction (10%–40%) in egg production in layers; but also because control requires intense vaccination.

Chronic or healthy carrier birds have long been recognized as the main reservoir of infectious coryza infection. The application of molecular fingerprinting techniques has confirmed the role of carrier birds in the spread of infectious coryza. Infectious coryza seems to occur most frequently in fall and winter, although such seasonal patterns may be coincidental to management practices. On farms where multiple-age groups are brooded and raised, the spread of the disease to successive age groups usually occurs within 1–6 weeks after such birds are moved from the brooder house to growing cages near older groups of infected birds. Infectious coryza is not an egg-transmitted disease.

Epidemiologic studies have suggested that *Av. Paragallinarum* may be introduced onto isolated ranches by the airborne route. There is no knowledge of the routes of transmission, carrier status, or vectors for *Av. gallinarum* or *Av. endocarditis*

The characteristic feature of infectious coryza is coryza of short incubation that develops within 24–48 hours post-inoculation of chickens with either culture or exudate. The latter will more consistently induce disease. Susceptible birds exposed by contact with infected cases may show signs of the disease within 24–72 hours. In the absence of a concurrent infection, infectious coryza usually runs its course within 2–3 weeks.

The most prominent features of infectious coryza are an acute inflammation of the upper respiratory tract including involvement of the nasal passage and sinuses with a serous to mucoid nasal discharge, facial edema, and conjunctivitis. Swollen wattles may be evident, particularly in males. Rales may be heard in birds with infection of the lower respiratory tract.

A swollen head-like syndrome associated with *Av. Paragallinarum* has been reported in broilers in the absence of avian pneumovirus but in the presence or absence of other bacterial pathogens such as *M. synovial* and *M. gallisepticum*. Arthritis and septicemia have been reported in broiler and layer flocks respectively. The presence of other pathogens contributed to the disease complex.

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Birds may have diarrhea, and feed and water consumption usually is decreased. There will be an increased number of cells in growing birds, and reduced egg production (10%–40%) in laying flocks. A foul odor may be detected in flocks in which the disease has become chronic and complicated with other bacteria.

The most common sign seen in outbreaks of disease where *Av. gallinarum* has played a potential role has been those of acute respiratory disease, coughing, and sneezing, with some outbreaks involving periorbital swelling.

3. METHODS

This section will discuss how the Best First Search (BFS) method and the Forward Chaining method solve the problem and define their performance.

3.1 The Best First Search Method

The best first Search algorithm is a common technique used to transverse graphs. This algorithm has the following procedure: [13]

1. Put the start nodes s on a list called OPEN of unexpanded nodes.
2. If OPEN is an empty exit with failure; no solutions exist.
3. Remove the first OPEN node n at which f is minimum (break ties arbitrarily), and place it on a list called CLOSED to be used for expanded nodes.
4. Expand node n, generating all its successors with pointers back to n.
5. If any of no's successors is a goal node, exit successfully with the solution obtained by tracing the path along the pointers from the goal back to s.
6. For every successor n' on n:
   a. Calculate f (n')
   b. If n' was neither on OPEN nor CLOSED, add it to OPEN. Attach a pointer from n' back to n. Assign the newly computed f(n') to node n'.
   c. If n' already resided on OPEN or CLOSED, compare the newly computed f(n) with the value previously assigned to n'. If the old value is lower, discard the newly generated node. If the new value is lower, substitute it for the old (n' now points back to n instead of to its previous predecessor). If the matching node n' resided on CLOSED, move it back to OPEN.
7. Go to the flowchart

The flowchart of the Best First Search method is shown in Figure 3.

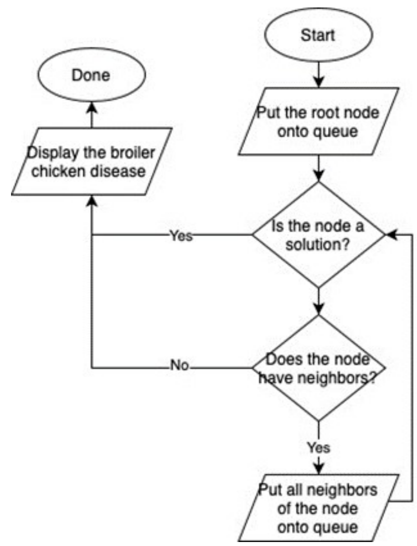

Figure 3: Flowchart of Best First Search Method

3.2 Forward Chaining Method

Forward chaining is one search method used in expert systems by collecting information facts about the problem to infer conclusions. The Forward chaining method can be used for monitoring and diagnostics systems because forward chaining can work quickly and solve problems [14]. The forward chaining operation starts by inputting the facts into working memory, then matching the fact with known rules. Defining the structure of data control rules written in the structure of IF-THEN and given several rules to distinguish the rules from each other. If the data matches, then the rule is executed and the operation stopped when no more rules can be executed. The flowchart of the Forward Chaining method is shown in Figure 4.

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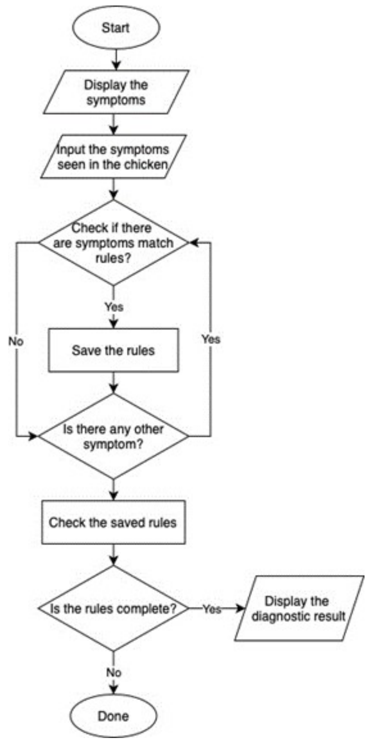

Figure 4: Flowchart of Forward Chaining Method

3.3 Research Methodology

The methodology to be used in this study is as shown in figure 5 below:

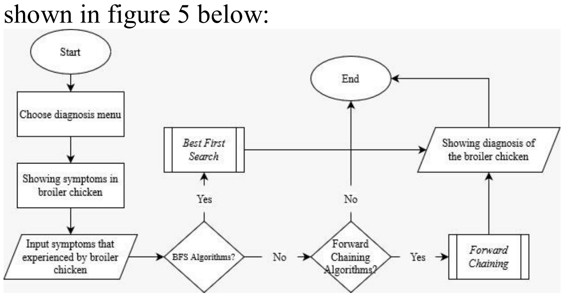

Figure 5: Flowchart of Research Methodology

4. RESULT AND DISCUSSIONS

4.1. Data Resources

Data sources used in expert systems to diagnose broiler chicken disease include symptoms and samples of broiler chicken disease cases. The data required in this study were obtained from the interview with experts, in this case, veterinarians.

4.2. Data Processing

Based on the interview results, given the source of the knowledge of symptoms that are used on the system. It shows in Table 1.

Table 1: Symptoms Table of Chicken Diseases

Code	Symptom
G1	Slimy nose
G2	Wings drooping
G3	Lethargic
G4	Decreased appetite
G5	Shortness of breath
G6	Head twisted or folded
G7	Sleepy
G8	Dirty in the anal area
G9	Diarrhea with vaginal discharge
G10	Bending body position
G11	Beak hangs down during sleep
G12	White stool and stick in the anus
G13	Comb swell with a bluish tint
G14	Hanging wings
G15	Decrease in production by more than 20%
G16	Sneeze
G17	Snoring
G18	Uniform bleeding on the legs in the form of red spots
G19	Discharge from the mouth either watery or thick
G20	Nodding looks like it's sleepy
G21	Discharge from chicken an eye
G22	Swelling on the face, especially in the eyes
G23	Mucus comes out of the nose and sting

4.3. Production Rules

Production rules are written in the decision table to save the relationship between data and symptoms of chicken diseases. This rule uses the relationship between the premise and the conclusion (IF-THEN). This relationship shows in Table 2.

Table 2: Table Relationship between Symptoms and Diseases

Rule	IF	THEN
1	G1, G2, G3, G4, G5, G6	Newcastle Disease (T)
2	G3, G7, G8, G9, G10, G11	Infectious Bursal Disease (G)
3	G3, G4, G12, G13, G14	Pullorum (B)
4	G9, G13, G15, G16, G17, G18, G19	Avian Influenza (F)
5	G5, G7, G17, G21, G22, G23	Snot (S)

4.2. Calculation

This step will be implemented in an expert system that can diagnose broiler chicken disease using both methods. The diagnostic results in this system will be compared with 20 existing sample data. From the comparison of the test with this sample data, it will be known which method is more accurate for diagnosing the disease of broiler chickens. The result shows in Table 3.

Table 3: The Best First Search and Forward Chaining Process Node.

Code	Symptom	Best First Search		Forward Chaining	
A01	G3, G6, G11	G	Invalid	T	Valid
A02	G15, G16, G20, G22	S	Valid	F	Invalid
A03	G3, G4, G12, G14	B	Valid	B	Valid
A04	G3, G6, G7, G8	G	Valid	G	Valid
A05	G1, G3, G6, G8, G9	G	Valid	T	Valid
A06	G9, G13, G15	H	Valid	F	Valid
A07	G4, G5, G6, G18, G19, G20	S	Invalid	F	Valid
A08	G1, G3, G5, G6	T	Valid	T	Valid
A09	G3, G7, G8, G9	G	Valid	G	Valid
A10	G1, G13, G14, G15	B	Valid	B	Valid

According to the results, the accuracy of the Best First Search method is 70% and the Forward Chaining method is 90%. It can be concluded that the Forward Chaining method is more accurate than the Best First Search method.

$$Accuracy_{BFS} = \frac{7}{10} \times 100\% = 70\%$$

$$Accuracy_{FC} = \frac{9}{10} \times 100\% = 90\%$$

4.3. Plus Minus Interesting

The plus-minus interesting is as shown in table 4 below:

Table 4: The Plus Minus Interesting

Plus	Minus	Interesting
The expert system for diagnosing broiler chicken diseases can provide diagnostic results based on the symptoms experienced by the chicken	Data on chicken symptoms available in this study is still small	Collect more chicken symptom data to increase the accuracy of the system in providing more accurate diagnostic results to users.

5. CONCLUSIONS

The results of this study showed that an expert system for determining broiler chicken diseases can provide diagnostic results based on the chicken symptoms by using comparative analysis of the Best First Search and Forward Chaining methods. The amount of data on chicken symptoms may affect the accuracy of the system. The level of system accuracy will be increased when the symptoms are added. The accuracy percentage obtained from the system's diagnostic results using the Best First Search method is 70%, while the Forward Chaining method is 90%. Therefore, it can be concluded that the Forward Chaining method is more accurate than the Best First Search method.

The data on the symptoms of chickens available in this study is still small, therefore for further research,

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

it is expected to collect more data on the symptoms of chickens to increase the level of accuracy of the system in providing more accurate diagnostic results to users.

Furthermore, it is expected to develop the benefits of this system so that the system not only provides diagnostic results but can provide treatment or prevention of disease transmission to other chickens.

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