

# Design of a Fuzzy Expert Based System for Diagnosis of Cattle Diseases

Agbonifo, Oluwatoyin C.

Department of Computer  
Science, Federal University of  
Technology, P.M.B 704, Akure,  
Nigeria.

Ajayi, Adedoyin O.

Department of Mathematical  
Sciences, Ekiti State University,  
Ado-Ekiti, Nigeria.

## ABSTRACT

Artificial intelligence (AI) is the core of computing research that makes machine to mimic the intelligence of a man. Intelligent means less of user interaction and automated adaptation to changing environment. When compared to other primitive techniques used in the past, AI has been highly efficient in knowledge acquisition in diverse areas of application. In the light of this, the paper focuses on intelligent technique of determining the possible diseases that affect the life of cattle. Hence, fuzzy expert technique is proposed for the diagnosis of the Antrax, Babesiosis, Blackleg and Epizootic Hemorrhagic diseases. The result generated by the system was sufficient to demonstrate its performance.

## Keywords

*Artificial Intelligence, Knowledge Acquisition, Fuzzy Technique, Cattle Diseases*

## 1. INTRODUCTION

The Cattle industry has become a rapid development industry in Nigeria. Livestock contribute about 12.7% of the total agricultural GDP of the country [5]. By the increasing number of breeding stock, along with a large number of both imported and domestic circulations of breeds, they have brought a great pressure on preventing and controlling cattle endemic diseases. It is estimated that, each year, cow's mortality from infectious diseases is up to 5% - 11%; as a result, economic losses have risen to as high as 32.5 million, in pounds, in recent years [10]. It is multitudinous in the threats to humans in health terms and these alarming statistics have hit the punters' confidence in the country. The fact that cattle breeding patterns have changed has led to new and bigger challenges to prevent and control endemic diseases that affect cattle livestock. Many farmers in Nigeria lack knowledge and experience about breeding and appropriate veterinary services, and do not know how to prevent these cow epidemic diseases. In vast majority of farms, there are deficiencies in diagnosis criteria of cattle epidemic diseases, shortage of experts, who have wealth of theoretical knowledge and practical experience, and paucities in capability of "early detection, early response" [14] [17].

According to Libin and Daoliang [14] and Xu et al [17], Medical Artificial Intelligence was introduced as a solution to overcome the problem of identifying the symptoms of diseases. Medical Artificial Intelligence is primarily concerned with the construction of Artificial Intelligence (AI) programs that perform diagnosis and make therapy recommendations [2]. The branch of artificial intelligence that is responsible for this process is called expert systems. An expert system is a class of computer program that can advise, analyze, categorize, communicate, consult, design, diagnose,

explain, explore, forecast, form concept, identify, interpret, justify, learn, manage, plan, present, retrieve, schedule, test or tutor. These systems encode human expertise in limited domains [17]. The demand for cattle disease incidence and prevalence data is increasing. Interests include well known infectious and metabolic diseases, as well as less obvious conditions resulting in sub-optimal production or performance. Data are needed for animal health risk assessments to facilitate world trade, benefit cost analyses of health maintenance programs and genetic evaluations for the enhancement of disease resistance [17].

According to Xu et al [17], the challenges of identifying and aggregating data from the required hundreds of thousands of cows in thousands of herds are substantial. The first of these is data quality, which encompasses accuracy, consistency, and completeness. Accuracy refers to how closely the data reflect the true state of nature. While some inaccuracies, such as the etiologic misclassification of mastitis caused by minor pathogens, may be tolerable, a mechanism to assess the overall frequency and magnitude of inaccuracies in the data is imperative. Consistency in defining and recording disease events is also very important. Important differences in classification of disease events are common in aggregate databases, particularly when information is provided or recorded by many people, often with varied backgrounds, experiences and training. It is important to realize that consistency and accuracy are not synonymous, since individuals can consistently make the inaccurate disease diagnosis. Disease events that cannot be tied to a specific animal or herd are not acceptable for use in genetic evaluations or health status determinations. Data accuracy may be affected by its perceived usefulness and the motivation of the person responsible for collecting and recording it [17]. It based on the process of diagnosis of diseases by order of symptoms of taxonomy and composition that we propose to develop a system of cattle endemic diseases using fuzzy logic extrapolations.

## 2. RELATED WORKS

Many diagnostic systems generate comprehensive records from which the probabilities of incidence and clinical finding for diseases can be determined as done in actual clinical practice, have been developed. One computer diagnostic system was developed for these purposes [15]. A major limitation of the system is that the list of differential diagnosis is not in the order of probability from highest to lowest. This is because the program does not include the probability of incidence and clinical findings for each disease [15].

Among current cattle diagnosis systems in existence is one developed by Gu [11] called cattle disease diagnosis system (CaDDiS). CaDDiS is a computer program which attempts to aid the diagnosis of certain common tropical diseases in cattle.

The system is based on a Bayesian belief network approach and evaluates the relative likelihood of a cow having any of these diseases given the observation of particular clinical signs [11]. The system uses the Bayesian Belief Network methodology described by Lauritzen and Spiegelhalter [13]. The system is parameterised using data collected from 41 veterinary experts.

Other existing diagnosis system include a Web Based Expert System for Milch Cow Disease Diagnosis System in China [14] [17]. According to Xu et al [17] a major limitation of expert systems developed using the Bayesian Belief Networks methodology is the non-availability of an order of probabilities of the incidence of diseases and clinical findings associated with them. This in turn makes the list of differential diagnosis of the systems not to be in their order of probability from highest to lowest.

This work attempts to overcome these shortcomings by making sure the diagnosis system depends on the clinician determining the important findings or forceful feature of the case which can be useful in separating possible look-alike diseases [7] [15].

### 3. OVERVIEW OF SOME OF THE CATTLE DISEASES

Some of the typical cattle diseases and detailed information about them are listed below:

#### a. Anthrax

This cause of sudden death has occurred in at least three areas in Utah, but is only seen sporadically. The organism will survive indefinitely in the soil and when conditions are right, multiply and cause a disease outbreak. A vaccine is available, but should only be used when cattle are grazed in known problem areas [8].

#### b. Blackleg

Blackleg is a fatal disease of young cattle. It produces an acute local infection, and the resulting blood poisoning leads to death. The name 'blackleg' derives from the fact that the site of infection is often a leg muscle, and that the affected muscle is dark in colour. Blackleg is an endemic disease in both developed and developing countries and is a well-known cause of financial loss to cattle raisers in many parts of the world. The disease is prevalent in the United States of America, India and other parts of Asia and Europe, Latin America, and Africa. In Nigeria, the economic losses of Zebu cattle alone to the disease have been estimated at US \$4. 3 million (=N= 600 million naira) annually [16]. Useh et al [16] concluded that blackleg is still endemic in Nigeria.

#### c. Epizootic Hemorrhagic

This disease in cattle is characterized by fever, anorexia, and difficulty swallowing. The swallowing disorders are caused by damage to the striated muscles of the pharynx, larynx, esophagus and tongue, and may lead to dehydration, emaciation, and aspiration pneumonia. Edema, hemorrhages, erosions, and ulcerations may be seen in the mouth, on the lips, and around the coronets. The animals may be stiff and lame, and the skin may be thickened and edematous. Abortions and stillbirths have also been reported in some epidemics [8].

#### d. Babesiosis

The clinical signs that develop during infections with *B bovis* or *B bigemina* are similar but the courses of the diseases differ markedly. Babesiosis due to *B bovis* is characterised by fever up to 42°C, anorexia, depression, increased respiratory rate particularly on exertion, muscle tremor, reluctance to move, anaemia and jaundice. These signs are often seen before parasites can be detected in blood smears. Clinical signs in babesiosis due to *B bigemina* develop late in infection when patent parasitaemias are usually advanced. Cattle do not appear to be as sick as those with *Bbovis*, but haemoglobinuria occurs more consistently, anaemia and jaundice occur more rapidly and death can occur with little warning. The fever during infections may cause pregnant cattle to abort and bulls to show reduced fertility lasting six to eight weeks. Cattle infected with *B bigemina* may exhibit irritability and aggression but signs of cerebral derangement such as circling, head pressing, mania and convulsions have only been reported in cases of *B bovis* infection. Severe cases of cerebral babesiosis are refractory to treatment. Cattle with advanced babesiosis are very susceptible to stress and sometimes collapse and die while being driven to a yard for treatment. Babesiosis is more severe in older cattle and is unusual in cattle less than 9 months old [8].

#### e. Foot-and-Mouth

Foot-and-Mouth Disease (FMD) is severe and highly communicable disease that primarily affects cloven-hooved livestock and wildlife, and is found in most African countries and it is caused by a virus [12]. According to Chukwuedo et al [6], the disease is characterised by blister-like lesions on the cattle tongue, nose and lips, the mouth, on the teats and between the toes which then burst, leaving painful ulcers.

Although adult animals generally recover, the morbidity rate is very high in naive populations, and significant pain and distress occur in some species. Symptoms may include decreased milk yield, permanent hoof damage and chronic mastitis. High mortality rates can be seen in young animals. Where it is endemic, this disease is a major constraint to the international livestock trade. Unless strict precautions are followed, FMD can be readily re-introduced into disease-free livestock. Once this occurs, the disease can spread rapidly through a region, particularly if detection is delayed. Outbreaks can severely disrupt livestock production, result in embargoes by trade partners, and require significant resources to control. John [12] reported that FMD is common to Fufore Local Government Area of Adamawa state, border town with Cameroon, in Northern Nigeria, where every year between three million and five million cows cross the border.

#### f. Grass Tetany

Grazing animals on pasture can be an integral part of an effective feeding regime for cattle and other livestock. Grazing reduces valuable labor time and cost for the farmer because no harvesting is needed and provides exercise for the animal; however, as with other feeding programs, it does not come without risk.

Tetany is typically found in ruminant animals, with lactating cows being the most susceptible [3] [17]. Grass tetany generally becomes a problem when the diets of cattle are changed from winter stockpiles (silages) to rapidly growing, lush, spring grasses [4] [17]. Testing may indicate high levels of potassium (K) and nitrogen (N) and low levels of

magnesium (Mg), calcium (Ca), and sodium (Na) in the soil [9] [17]. Incidences of grass tetany are seasonal and more common when the weather is cool and rainy. Pastures prone to cause grass tetany include, but are not limited to, a wide variety of warm season grasses such as orchard grass, perennial ryegrass, tall fescue, timothy, and bromegrass. When grazed, small grains such as wheat, barley, oats, and rye can also cause grass tetany. Lastly, grass tetany can occur in livestock that are wintered on low Mg grass hay or corn stovers [3][17].

#### 4. SYSTEM DESIGN

##### 4.1 System Architecture

The system architecture of this application is a three layered design of the internal structure of the system in relation to the technology platform on which the system is based. As shown in Figure 1, the layers include the following:

- i. application layer
- ii. business layer and
- iii. storage layer.

The storage layer is implemented using the object oriented system design. The business logic layer is where the system specification functionality resides, including all the application classes and their various functions. Finally, the application layer covers all the interfaces to the system: the User Interfaces and the layer at which the target application users operates. The business logic layer is made up of the database and all the tables used to store the records.

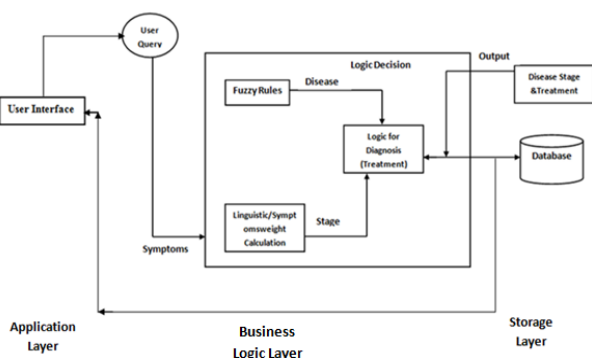


Figure 1: An Architectural diagram showing the different layers of the system

##### 4.2 Fuzzy Rule-Based System

The schematic diagram of the fuzzy rule-based system as shown in Figure 2 is composed of three major components, namely:

- i. fuzzification module
- ii. fuzzy rule base and
- iii. fuzzy inference engine.

A fuzzy inference system (FIS) essentially defines a nonlinear mapping of the input data vector into a scalar output, using fuzzy rules. The mapping process involves input/output membership functions, fuzzy logic operators, fuzzy if-then rules, aggregation of output sets, and defuzzification. An FIS with multiple outputs can be considered as a collection of independent multi-input, single-output systems [1]. The Fuzzy Logic System (FLS) maps crisp inputs into crisp outputs. It can be seen from the figure

that the FIS contains four components: the fuzzifier, inference engine, rule base, and defuzzifier. The rule base contains linguistic rules that are provided by experts. It is also possible to extract rules from numeric data. Once the rules have been established, the FIS can be viewed as a system that maps an input vector to an output vector. The fuzzifier takes input values and determines the degree to which they belong to each of the fuzzy sets via membership functions.

The inference engine defines mapping from input fuzzy sets into output fuzzy sets. It determines the degree to which the antecedent is satisfied for each rule. If the antecedent of a given rule has more than one clause, fuzzy operators are applied to obtain one number that represents the result of the antecedent for that rule. It is possible that one or more rules may fire at the same time. Outputs for all rules are then aggregated. During aggregation, fuzzy sets that represent the output of each rule are combined into a single fuzzy set. Fuzzy rules are fired in parallel, which is one of the important aspects of an FIS. In an FIS, the order in which rules are fired does not affect the output. The defuzzifier maps output fuzzy sets into a crisp number.

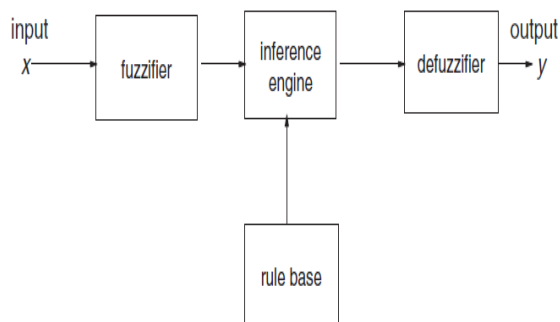


Figure 2: Schematic diagram of the fuzzy rule-based system

The schematic diagram of the fuzzy inference engine is depicted in Figure 3 showing how various inputs (symptoms) are fuzzified by firing the appropriate production rule after which the output (disease) would be displayed.

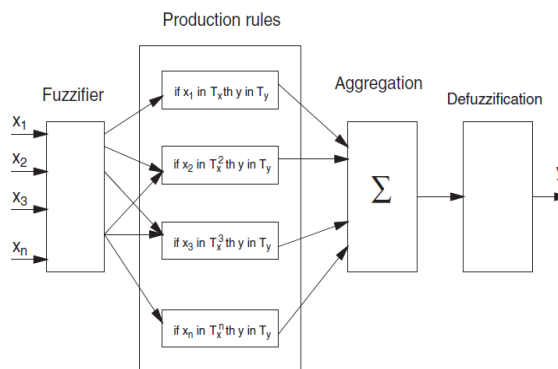


Figure 3: Schematic diagram of the fuzzy inference system

A fuzzy rule base contains a set of fuzzy rules  $R$ . A single if-then rule assumes the form “if  $x$  is  $T_x$  then  $y$  is  $T_y$  .” The procedure for the fuzzy algorithm is described as follows:

Step 1: Display the list of all the symptoms from the database

Step 2: Select the particular symptom of concern to be diagnosed. (here the weight of the symptom is also taken into consideration)

Step 3: Select the level of severity for each selected symptoms. (Here, linguistic values are assigned to all the severity level as follows: Very high = 0.95, High = 0.76, Medium = 0.57, Low = 0.38, Very low = 0.19)

Step 4: for each selected symptoms, search the database for all the diseases that has the symptom and then select then select the weight of the symptom and multiply it by the appropriate linguistic variable. That is:

FOR EACH Selected symptom in All Disease

IF Symptom is present THEN

Disease<sub>i</sub> = Weight<sub>i</sub> \* LinguisticVariable<sub>i</sub>

END IF

END FOR EACH

$$\sum_{i=1}^n Disease_i = Symptoms_i * LinguisticVariable_i$$

where i=1 to n , where n is the total number of disease diagnosed

Step 5: Select the disease with the highest value after summation has been carried out in step four and display its corresponding disease. This is the diagnosed disease. That is:

IF Disease<sub>i</sub> > 0

Select the highest disease

END IF

Step 6: Display disease<sub>i</sub> after the diagnosis of the disease, the diagnosed disease is displayed in the application.

### 4.3 Fuzzy Rules Used For Cattle Disease Diagnosis System

The Table 1 and Table 2 showed the linguistic variables, membership values and some symptoms found in infected cattle.

Table 1. Linguistic Variable and Membership Value

Linguistic Variable	Linguistic Value
Very High(V.H)	0.95
High(H)	0.76
Medium(M)	0.57
Low(L)	0.38
Very Low(V.L)	0.19

Table 2. Some of the possible Symptoms

Symptom Symbol	Symptoms
S <sub>1</sub>	Fever
S <sub>2</sub>	Diarrhoea
S <sub>3</sub>	Lameness
S <sub>4</sub>	Abortion
S <sub>5</sub>	Anorexia

Some of the rules showing the relationship between the fuzzy sets as shown in Table 1 and the symptoms shown in Table 2 are discussed below.

RULE 1: If S<sub>1</sub> = M AND S<sub>2</sub> = V.H AND S<sub>3</sub> = V.H AND S<sub>4</sub> = V.H AND S<sub>5</sub> = V.H THEN X = 'Blackleg'

RULE 2: If S<sub>1</sub> = M AND S<sub>2</sub> = V.L AND S<sub>3</sub> = H AND S<sub>4</sub> = V.L AND S<sub>5</sub> = V.L THEN X = 'Mastitis'

RULE 3: If S<sub>1</sub> = V.L AND S<sub>2</sub> = V.L AND S<sub>3</sub> = V.L AND S<sub>4</sub> = V.L AND S<sub>5</sub> = V.H THEN X = 'Epizootic Hemorrhagic'

RULE 4: If S<sub>1</sub> = V.L AND S<sub>2</sub> = V.L AND S<sub>3</sub> = H AND S<sub>4</sub> = M AND S<sub>5</sub> = V.H THEN X = 'Epizootic Hemorrhagic'

RULE 5: If S<sub>1</sub> = V.H AND S<sub>2</sub> = V.H AND S<sub>3</sub> = V.H AND S<sub>4</sub> = M AND S<sub>5</sub> = V.H THEN X = 'Blackleg'

RULE 6: If S<sub>1</sub> = H AND S<sub>2</sub> = V.H AND S<sub>3</sub> = V.H AND S<sub>4</sub> = V.L AND S<sub>5</sub> = V.L THEN X = 'Grass tenany'

RULE 7: If S<sub>1</sub> = H AND S<sub>2</sub> = H AND S<sub>3</sub> = V.H AND S<sub>4</sub> = V.H AND S<sub>5</sub> = V.H THEN X = 'Grass tenany'

RULE 8: If S<sub>1</sub> = H AND S<sub>2</sub> = V.L AND S<sub>3</sub> = M AND S<sub>4</sub> = V.L AND S<sub>5</sub> = V.H THEN X = 'Blackleg'

RULE 9: If S<sub>1</sub> = V. L AND S<sub>2</sub> = V.H AND S<sub>3</sub> = M AND S<sub>4</sub> = V.H AND S<sub>5</sub> = V.L THEN X = 'Epizootic Hemorrhagic'

RULE 10: If S<sub>1</sub> = V. L AND S<sub>2</sub> = V.H AND S<sub>3</sub> = M AND S<sub>4</sub> = V.H AND S<sub>5</sub> = L THEN X = 'Blackleg'

## 5. RESULT AND DISCUSSION

The system is accessed through the home page as depicted in Figure 4. Thereafter, all the modules were successfully tested which made for complete system testing to have been carried out. The system testing helped ensure requirements and design conformance. The procedure of system testing follows that: the clinician selects from the displayed symptom(s) on the Disease Diagnosis page as shown in figure 5, the symptoms present in cattle as complained by the complaint. The degree of the severity associated with the symptom(s) (Very high, High, Medium, Low and Very low) is also selected. Thereafter, clinician proceeds to click on the 'Diagnose' button where disease(s) that could be present in the cattle based on the supplied symptoms are then displayed in the descending order of severity. The result generated by the system showed that diagnostic status was successful as depicted in Figure 6, which is also evident that the

performance of the system is considerably effective and efficient.



Figure 4: Home page of the System

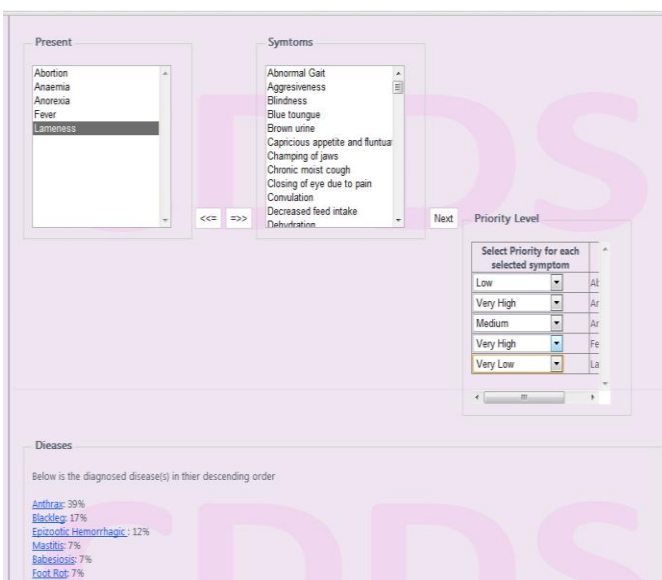


Figure 5: Disease Diagnosis Page

ComplainantName	ComplainantPhoneNumber	AnimalType	AnimalAge	DiagnosedDisease	Remark
Ada Fern	0803456789	Cow	8	Anthrax, Babesiosis, Blackleg, Epizootic Hemorrhagic	Successful
Ope Bamidele	089202010101	Cow	9	Anthrax, Babesiosis, Epizootic Hemorrhagic, Blackleg	Successful
Bimbo Osuntuyi	08032992922	Calf	10	Anthrax, Babesiosis, Epizootic Hemorrhagic, Blackleg	Successful
Andro Lawrence	02030330303	Cow	1	Anthrax, Babesiosis, Blackleg, Epizootic Hemorrhagic	Successful
Tola Araoye	09032993933	Cow	1	Anthrax, Babesiosis, Blackleg, Epizootic Hemorrhagic	Successful
Bamidele Opeyemi	080239493020	Cow	5	Mastitis	Successful
Kunle Dada	06059403933	Cow	1	Mastitis, Babesiosis, Blackleg, Epizootic Hemorrhagic	Successful
Tunde Kolade	08288910111	Calf	7	Anthrax, Epizootic Hemorrhagic, Mastitis, Babesiosis, Blackleg	Successful
Kunle Ajayi	08043039302	Calf	2	Anthrax, Epizootic Hemorrhagic, Mastitis, Babesiosis, Blackleg	Successful
Adeleke Kayode	080335678383	Calf	4	Mastitis, Babesiosis, Blackleg, Epizootic Hemorrhagic	Successful
Anke Samuel	08043039302	Cow	1	Anthrax, Epizootic Hemorrhagic, Anaplasmosis, Trichomoniasis	Successful
Dammy Dayo	080335678383	Cow	4	Anthrax, Blackleg, Epizootic Hemorrhagic, Mastitis, Babesiosis, Foot Rot, Trichomoniasis	Successful
Anke Dayo	080335678383	Calf	8	Anthrax, Epizootic Hemorrhagic, Mastitis, Babesiosis, Blackleg, Anaplasmosis, Trichomoniasis	Successful
Adeleke Henry	080335678383	Cow	1	Anthrax, Epizootic Hemorrhagic, Anaplasmosis, Trichomoniasis	Successful
Anke Shade	08043039302	Cow	2	Anthrax, Mastitis, Babesiosis, Epizootic Hemorrhagic, Blackleg, Anaplasmosis, Trichomoniasis	Successful
Mafe Ibukun	080335672422	Cow	3	Anthrax, Epizootic Hemorrhagic, Mastitis, Babesiosis, Foot Rot, Anaplasmosis, Trichomoniasis	Successful
Seun Kunle	080335672333	Calf	4	Anthrax, Epizootic Hemorrhagic, Anaplasmosis, Babesiosis, Mastitis, Trichomoniasis, Blackleg	Successful
Seyi Olabukun	080335672333	Calf	7	Blackleg, Grass tetany, Anthrax, Epizootic Hemorrhagic, Babesiosis, Mastitis	Successful

Figure 6: Diagnostic Cattle Record Page

## 6. CONCLUSION

The focus of this paper is to provide an optimized, fast and accurate system for the diagnosis of cattle diseases. To achieve this, fuzzy logic was integrated into the system to obtain a precise classification of the cattle disease based on their symptoms. Providing this diagnosis system for the veterinary doctors would greatly improve their performance in terms of reliability, speed and accuracy in diagnosing of diseases. This system can also be used in the absence of clinicians to diagnose diseases because the system is independent of the clinician; it works based on the expert knowledge built into it. A reliable and secured database system is also in place to keep record of cattle and their individual diagnosed diseases. The work can be extended using the combined features of neural network and fuzzy logic to improving disease diagnosis in cattle.

## 7. REFERENCES

- [1] Adlasing, K.P. 1986. Fuzzy set theory in medical diagnostics, IEEE Trans. On Systems, Man, and Cybernetics, Vol. SMC-16(1986) 260-264.
- [2] Akinoyun, O. C. 1991. Computer Aided System for Medical Diagnostic and Therapy, International Centre for Informatics Research and Development, Lagos.
- [3] Allison, C. 2003. Controlling Grass Tetany in Livestock. Cooperative Extension Service. College of Agriculture and Home Economics. New Mexico State Univ. Guide B-809.
- [4] Caley, H. 1991. Grass Tetany. Kansas State Univ. Agricultural Experimental Station and Cooperative Extension Service. MF-976.
- [5] CBN 1999. Central Bank of Nigeria Annual report 1999. CBN, Lagos, Nigeria.
- [6] Chukwuedo, A.A., Abegunde A., Nimzing L. and Gomwalk N.E. 2007. Losses Due To Foot and Mouth Disease Outbreak In Nigerian Livestock. Animal Production Research Advances 3 (3): 254 -255.
- [7] COVM 2012. Cornell University College of Veterinary Medicine. Abstract available at: <http://www.vet.cornell.edu/>. Retrieved on May, 2012.
- [8] CWE (Cattle Website Experts). Cattle Today Online, Inc. Available: <http://cattletoday.info/index.html> Retrieved on August, 2011.
- [9] Elliot, M. 2007. Grass Tetany in cattle. NSW Department of Primary Industries. Primefacts. Primefact 420.
- [10] FAO 2012. Distribution and impact of helminth diseases of livestock in developing nations. Available at [www.fao.org/DOCREP/004/T0584E/T0584E03.htm](http://www.fao.org/DOCREP/004/T0584E/T0584E03.htm). Retrieved on May, 2012
- [11] Gu, Y. 2012. Cattle Disease Diagnostic System (CaDDiS). Available at [http://vie.dis.strath.ac.uk/vie/CaDDiS/docs/Project\\_Team.html](http://vie.dis.strath.ac.uk/vie/CaDDiS/docs/Project_Team.html). Retrieved on January, 2012.
- [12] John, N. 2012. Nigeria: Cattle Foot and Mouth Disease Resurfaces in Adamawa. Available at

<http://allafrica.com/stories/201204250176.html>.  
Retrieved on May, 2012.

- [13] Lauritzen, S. and Spiegelhalter, D. 1988. Local computations with probabilities on graphical structures and their application to expert systems. *J. Royal Statistical Society B*, 50: 157-224.
- [14] Libin, R. and Daoliang, L. 2007. A web based expert system for milch cow disease diagnosis in China. Available at [www.dplp.l3s.uni-hannover.de/topics/expertsystems](http://www.dplp.l3s.uni-hannover.de/topics/expertsystems). Retrieved on August, 2011.
- [15] Radostits, O.M. and Arundel, J. H. 2012. *Veterinary Medicine: A Textbook of the Diseases of Cattle, Sheep, Pigs*. Available at: [http://books.google.com.ng/books/about/Veterinary Medicine.html?id=Kqw2gCZFhoC&redir\\_esc=y](http://books.google.com.ng/books/about/Veterinary_Medicine.html?id=Kqw2gCZFhoC&redir_esc=y). Retrieved on January, 2012.
- [16] Useh, N.M, Adamu, S., Ibrahim, M., Nok, A.J. and Esievo, K.A.N. 2010. Outbreaks of blackleg of cattle in northern Nigeria (1964-2003). Slovenian National AGRIS Centre. Available at [http://agris.fao.org/agrissearch/search/display.do?f=2011%2FSI%2FSI1101.xml%3Bsi2011 000056](http://agris.fao.org/agrissearch/search/display.do?f=2011%2FSI%2FSI1101.xml%3Bsi2011%2000056). Retrieved on May, 2012.
- [17] Xu, J., Dong, J. H., Lin, S. Z., Jing, Y. W. and Jing, Z. 2010. Research on Cow Epidemic Disease Diagnosis Based Certainty Factor. *Applied Mechanics and Materials*, Vol. 29 - 32 pp. 1223-1228.