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Towards a Balanced Nutrition System

Using Fuzzy Logic in Livestock

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Abstract

Livestock health issues have always been a major concern in the animal production. Although, the common solution is to give proper care and nourishing food, farmers ignore the fact that each and every livestock varies in characteristics, which also requires changes in the nutritional intake. In this paper, we suggest a nutrition control system using fuzzy logic technique to take care of the uncertain data from various parameters that affects the nutritional imbalance in the livestock. The CowStage, Weight, Health and PregnancyStage are considered the basic functionality that determines the nutrition requirement in the cow. Hence, the fuzzy technique is applied to determine the nutrition requirement and the quantity of food intake that needs to be served, after accessing the daily food assignment. As each cow has different health issues, using this model, ensures a balanced diet for each and every cow, and also facilitates to maintain proper health.

Keywords: Fuzzy Logic, Nutrition System, Ontology, Livestock

1 Introduction

It is statistically proven that the demand and dependency for the dairy products and the meat consumption has increased rapidly over the past few years.

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Given the increase in the population each year, it is evident that the demand for the dairy product will continue increasing. Now, the major concern in the livestock farm is the health of the cow that may affect the production. With the ontology, the relationship of the entities and the reasoning are performed, to execute a seamless automation [1]. Even after knowing the relationship, the decision over the nutritional needs for each livestock remains as a prolonging issue.

To resolve this issue, the fuzzy logic technique is utilized. The fuzzy logic is similar to human thinking [2]; therefore, it is widely used in the decision support system. The number of variables is chosen after determining the relationship between the input and the output, also called as linguistic variables. The membership function is used to define the values of linguistic variables designed in the fuzzy logic rules. Such defined rules offer a valued decision support over the vague data. On the whole, fuzzy logic is used that helps to reduce the uncertainty over the data and to obtain the absolute results [3]. Such researches on the livestock include the Fuzzy BMI, estrus detection, herd management and so on [4, 5]. In this paper, a fuzzy logic method along with the ontology is used to make a diet planner by determining the nutritional requirement of each cow in the livestock environment. The proposed system mainly focuses on the livestock's diet, in regard to the age, weight, health and pregnancy phase of the cow, to model a proper diet plan for the livestock.

2 Related Works

In this digital world, Internet of things has been advanced in the fields of the communication and information, especially on the internet and the sensory devices, also links them with the set of relationship with the domain of interest. Wireless sensor network has also taken forms and increased its usage in day-to-day life. Although, the purpose of WSN was to serve the military grounds, due to enormous development, it is being used in the health monitoring, agriculture, irrigation, transportation and in many smart applications [6, 7]. Many researches indicate that most problems related to the reproduction and the infertility of the cows happen due to the improper diet [8]. Farmers always blindly expect more result, simply by increasing the amount of feed, but always end up in disappointment. There are also more researches pointing problems in the cow such as heart disease, embryonic mortality and so on [9, 10]. The annual production cycle for the cow can be divided into four phases such as Pre-calving, Postpartum, Lactating and Pregnant, and Gestation, that has different nutrition requirement respectively. With the barn full of cows, it is significant to distinguish the proper nutrition required for the cow and decide the diet plan for every cow.

In this paper, we have discussed the diet planning mechanism of the livestock through the fuzzy logic algorithm. With the different combination of the

input variables, we use a fuzzy logic technique for better decision making services. Some researches include the fuzzy logic for the evaluation of BMI values in the livestock [11]. To determine the diet of the livestock, some of the major concerns are age, weight, health and the pregnancy phase of the cow. Researches also clarify that there are changes in the nutrition requirement during the different phase of the pregnancy. Therefore, the pregnancy phase is also included during the calculation of nutrition. All the possible inputs are considered for the fuzzy logic to produce a proper diet plan for the livestock.

3 Balanced Nutrition System Using Fuzzy Logic

Figure 1 shows the system structure of the suggested balanced nutrition system using fuzzy logics, where the nutrition facts received from the domain experts are used to calculate the daily Total Density Nutrition (TDN) required in the livestock through the fuzzy logic technique. In case of the healthy cow, the change nutrition requirement may not vary, but according to the health and the pregnancy of the cow, there is a relatively high difference in the nutrition requirement. To resolve such ambiguous data, a fuzzy logic technique is applied to find the proper nutritious diet for the respective cow.

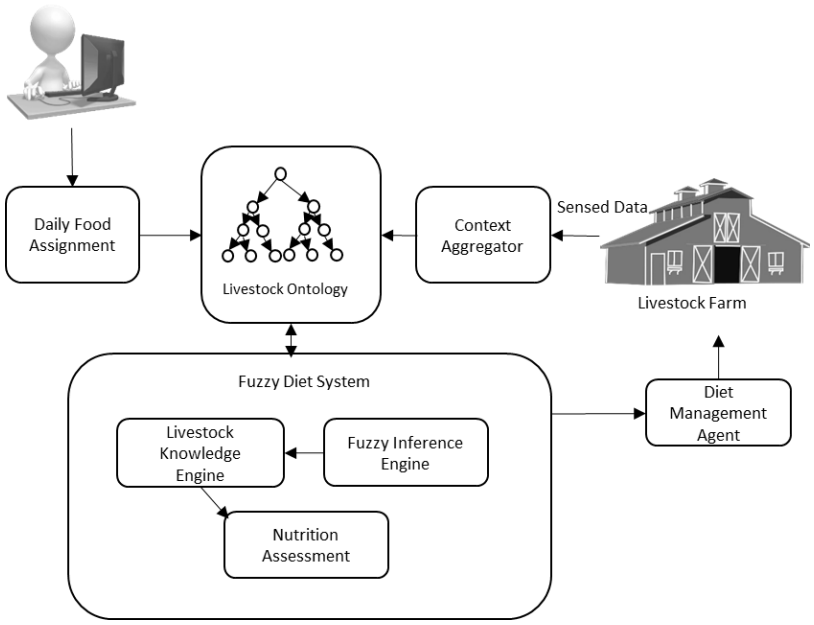

Fig 1. The system structure of the suggested balanced nutrition system

The Context Aggregator gains various raw-level context information from the sensory devices in the livestock farm through the wireless sensor networks. The Livestock ontology model receives the context information and the daily food assignment, where the entities are predefined with a clear relationship with the

domain. With the obtained information such as age, weight, health and pregnancy phase of the livestock, the fuzzy logic is applied to obtain the nutrition requirement in the livestock. By acquiring the nutrition percentage, the amount of the food required for the livestock is determined. The daily food assignment is done, with the amount of food available in the food stock, which is further used to determine the amount of food, after calculating the nutrition requirement.

4 Method and Analysis

In the selection of livestock for sale, there are two major aspects that need to be considered in the livestock stock market. One is the health aspect and another is quality aspects. Periodic health checkups are supposed to be performed to assure the condition of livestock health. In many rural places, the sick livestock is slaughtered for meat consumption. Such kinds of practices are prohibited as it may result in food poisoning or transmission of the disease. So the health of the livestock is given most care. Even though the health checkup is conducted regularly, there are genetic cases where the livestock doesn't gain weight even after passing the maturity.

Table 1: Input and Output variable of the fuzzy set [12]

Age	Calf	[0 0 2.5]
	Cow	[1 3 5]
	MatureCow	[3.5 6 8]
Weight	Underweight	[1000,1200,1300]
	Normal	[1200,1300,1400]
	OverWeight	[1300,1400,1600]
Health	UnHealthy	[0,0,0.4]
	Healthy	[0.1 0.5 0.9]
	VeryHealthy	[0.6 1 1.4]
PregnancyPhase	Postpatrum	[0 0 33]
	Lactating	[0 33 66]
	Gestation	[33 66 100]
	PreCalving	[66 100 133]
NutritionRequirement	Low	[-4 0 4]
	Normal	[1 5 9]
	High	[6 10 14]

In the suggested fuzzy logic system, the variables considered for the inputs are "Cowstage", "Weight", "PregnantPhase" and "Health". The input "Cowstage" is the age of the cow, where it differs from "Calf", "Cow" and "MatureCow". Apart from this, the nutrition of the cow has to be differed from the others during the pregnancy and lactation. Therefore, the PregnantPhase is also used, which has the

phases such as “Postpatrum”, “Lactating”, “Gestation” and “PreCalving”. The input variable, Health, is divided into “Unhealthy”, “Health” and “Veryhealthy”. Similarly, the Weight is divided into “Underweight”, “Normal” and “Overweight” as shown in Table 1, referred from our work [12].

The output variables in the suggested nutrition system are determined to have a nutrition density that helps in the planning the food schedule for the cow using the ontology model. With the four input variables, the rules are written in the fuzzy rule base. In the fuzzy logic system, the input variables are gathered with the logical operators (OR, AND) to form a fuzzy set. To be brief, the rules are created with an IF – THEN method for the selection of the control system. For an example, a possible combination using the four input variables with each other and the logical operators can be as follows.

IF (Weight == Normal) AND (CowStage == Cow) AND (Health == VeryHealthy) AND (PregnancyPhase == Gestation) THEN (NutritionRequirement == Low)

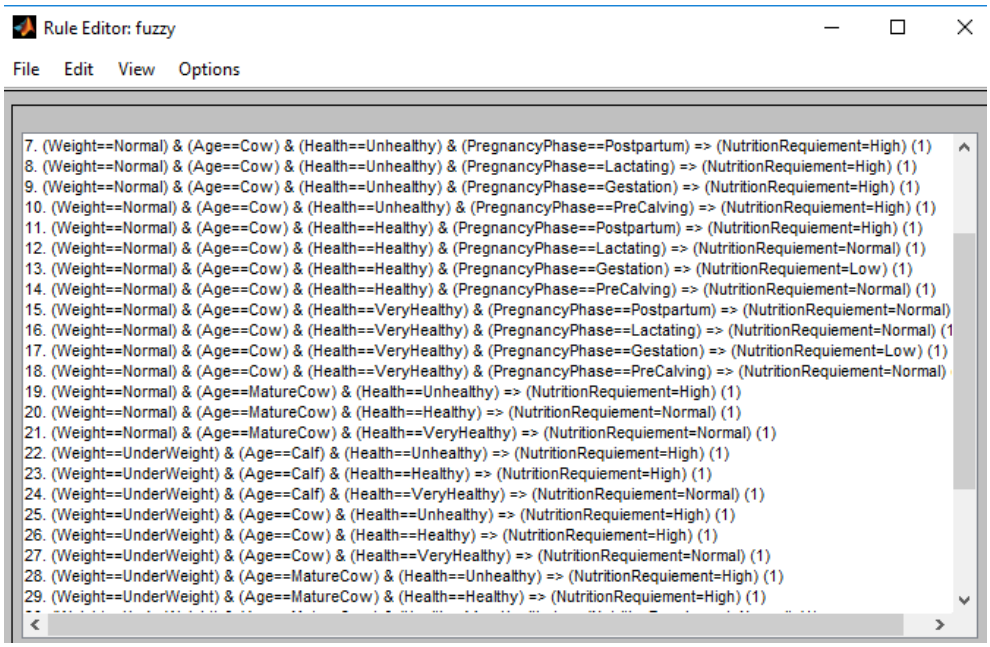

Fig 2. The Combinations of the rules in the suggested fuzzy system

According to the example combination, the cow is very healthy and in its Gestation phase during Lactation needs less nutrition, because, the lactation has been ceased and it doesn’t require more protein or energy. Similarly, the possible rule combination of all inputs can be obtained. Through the combination of the rules, we can properly have a nutrition plan according to the environmental conditions. Figure 2 shows a part of the possible rule combination in the MATLAB

fuzzy toolbox. The toolbox helped to increase the values of the most important part of the information that will give the most exact example to the process.

Using Mamdani inference method in the MATLAB fuzzy logic system, the simulated results are obtained for the before mentioned rule are shown in the figure 3, which is referred from our work [12]. In this simulation, the weight is 1300 lbs with the CowStage, that represents the age of the cow, 4 years, the health percentage is 0.4, and the PregnantPhase is 54, resulting in the output of 4.02 indicating "Normal".

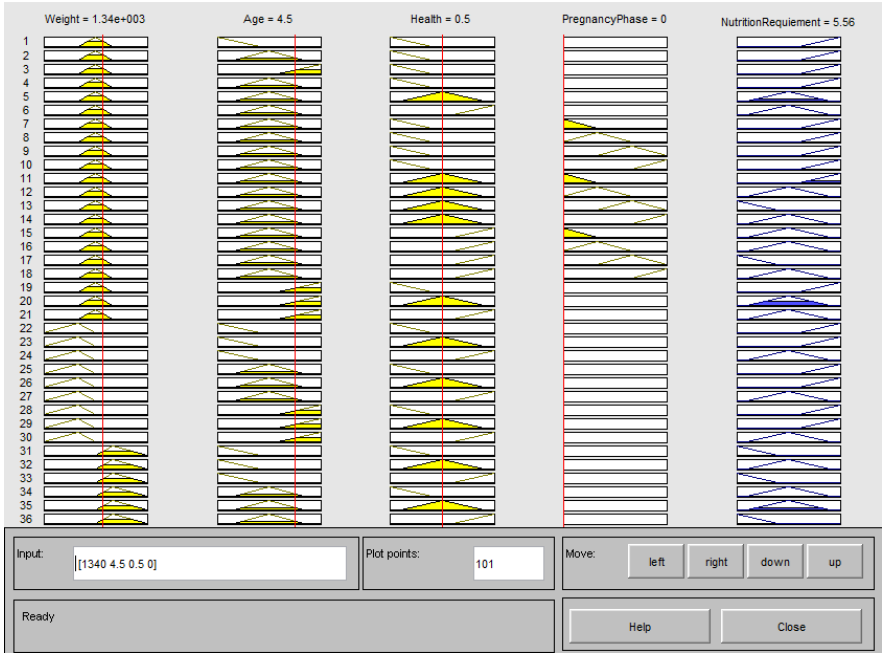

Fig 3. Simulated result in Mamdani's inference method [12]

If the nutrition requirement is Low, the amount of food given is reduced with respect to the TDN of the food. Let us consider the food given to the cow to be Hay. The amount of feed given to the cow is 12.5% of its body weight, as shown in the equation below,

$$Amount\ of\ feed = Weight * 0.0125$$

For the same example as below, if the cow's weight is 1300 lbs, then the calculated amount of feed is 16.25 lbs. As per the table 2, the Hay contains 55% of TDN and 9.7% protein, which makes the nutrition values high. Therefore, the amount of feed is reduced to 2% from the actual amount of feed. So for each cow, the diet is planned according to the fuzzy system along with the food assigned.

Table 2. Nutrition values of the Food Roughage for cow

Food Roughage	Total Digestible Nutrient (TDN)%	Crude Protein (CP) %
Hay	55%	9.7%
Corn	77.2%	8.0%
Soybean meal	77.9%	48.0%
…	…	….

5 Conclusion

In this paper, the fuzzy logic was incorporated along with a context-aware livestock model for the decision making in the diet plan by calculating the nutrition requirement for the livestock. With the basic input cow stage, pregnant phase, health and weight, we can properly control nutrition of cows using the set of defined fuzzy rules. Due to the logical interpretation of the fuzzy logic, the prediction is accurate and trustful. For the future works, we are planning to interfuse the fuzzy logic to type-2 fuzzy logic system along with the livestock ontology model to have more selection in the diet planning system.

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