Sheep movement patterns for early detection of deaths and flock abandonments

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ABSTRACT

This document presents an initial endeavor to develop a real-time anomaly detector for a population of sheep whose positions are tracked through satellite-level sensors. The focus is primarily on two anomalies: death and separation from the flock. The proposed method and its key features are examined based on its performance on a simulated sheep flock.

KEYWORDS

Sheep health behaviors, Welfare monitoring, Precision management, Production enhancement, Automated assessment, Simulation

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1 INTRODUCTION

The livestock industry represents a fundamental component of the economy in many countries. Efficient health control techniques in individuals are necessary to ensure proper care of the animals and prompt attention to diseases and abnormalities. The detection time of these anomalies is crucial, as it would allow for better resource management and prevent substantial losses for farmers. In this regard, it is urgent to develop mechanisms for controlling and early detecting anomalies in animal populations.

The sheep is a species of major global attention. The study of their behavior patterns and the relationship between diseases and changes in these patterns has become of interest to farmers. Numerous attempts have been made to detect anomalies in sheep behavior based on their movement, position, and even acceleration [1][5]. This work represents an effort to contribute to these anomaly detection mechanisms, particularly in the case of deaths and flock abandonments.

For this purpose, a storage matrix containing the last positions of the sheep in a simulated flock, measured every five seconds, was utilized. Based on the relationships between these positions, it is determined whether there is a flock abandonment or a death. The anomaly detector code and the simulation are available in the following public repository.

2 CONTEXT

The program is developed based on the following assumptions: there is a flock of n sheep with GPS sensors that capture the position (x_i, y_i) of the i-th sheep at constant time intervals t. The latency in sending positions from the sensors to the program will be ignored, and it is assumed that they are sent as ordered pairs whose coordinates are measured with respect to a known reference axis. Additionally, a rectangular protected area with known edge coordinates is conceived.

3 METHOD

The method employed is relatively simple. A position matrix $M \in \mathbb{M}_{n \times l}(\mathbb{R})$ is constructed, where n is the number of sheep in the studied flock and l is the number of position measurements that will be considered to examine the behavior of an individual. For example, if anomalies are to be reviewed every ten sheep position captures, the value of l will be 10. Each time the l position captures are completed, it is examined whether there is any possible death, and the matrix is reset with new sheep positions.

3.1 Herd abandonment

In the developed simulation, this check is straightforward because there is access to the dimensions of the protected area rectangle. It is simply determined if each position coordinates fall outside the range covered by the rectangular region. However, this process is not always as simple in a real scenario. It would be necessary to rotate the positions to center the rectangle of the protected region. Once this adjustment is made, the procedure can proceed as in the initial case, checking if the coordinates of each position fall outside the range covered by the sides of the rectangle. One of the advantages of the method based on capturing positions in a matrix is that rotation is simply achieved by multiplying this matrix by a rotation matrix.

3.2 Deaths or Injuries

For this purpose, an integer value w_j associated with the j-th sheep is defined, initialized to 0. Once the recording of nl positions for all the sheep is completed, the Euclidean squared distance between each pair of consecutive points is calculated for each row i of M,

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and these values are summed:

$$v_i = \sum_{i=1}^{l-1} d^2(i, i+1) \tag{1}$$

This summation of distances associated with the i-th sheep quantifies the position variation of each individual. If $v_j = 0$ for the j-th sheep, 1 is added to the value of w_j. If, on the other hand, $v_j > 0$, the value of w_j is reset to 0. Depending on the value of t, the value of w_j considered synonymous with a death could vary. Since the sleep cycle of sheeps comprises around $4-5$ hours of sleep [1] and part of their daily routine is spent in rumination periods, an appropriate limit value for issuing alerts of possible death or injury is one that coincides with an immobility period exceeding seven or eight consecutive hours. This maximum value W can be calculated using:

$$W \geq \frac{8 \cdot 3600}{lt} \tag{2}$$

where t is given in seconds.

The developed program issues alerts when $w_j = l - 1$ is reached for any sheep. This could be a warning sign for the farmer to approach the individual and check if they are okay.

3.3 Complexity

Let f be the number of arithmetic operations performed by the program. Then, f is a function of n, l, and W. In fact, $f(n, l, W) = O(nlW)$ could be a good approximation. From this reasoning, it follows that the complexity can arise with the increase in the number of sheep and the number of positions to consider before each examination of possible deaths. Despite the fact it is true that it is not a purely efficient method, its real-time attention and its almost complete effectiveness for small flocks make it worthy of consideration.

4 PREVIOUS WORKS

Past research highlights the relationship between behavior patterns and animal health [4][2]. Additionally, works such as those by [6][3] have utilized machine learning and big data for the detection of anomalies more specific than those presented in this paper. In these works, accuracy rates close to 100% are achieved. It is worth noting that the anomaly detection approach developed in this work is limited by the complexity discussed earlier. However, its programming specificity makes it effective with a significantly reduced error rate. Thus, it could be implemented as an alternative, verification, or emergency method in a sheep behavior tracking system that primarily uses machine learning.

5 CONCLUSIONS

Monitoring and early detection of strange behaviors and anomalies in sheep activity are crucial topics for the modern livestock industry. The information provided by automated behavior tracking systems is vital for effective decision-making in herd care. These early and accurate decisions help prevent losses and excessive resource wastage.

Sensor-based controls provide a real and powerful mechanism for monitoring animal behaviors, which can translate into early detection of all kinds of anomalies. The correlation between these special behaviors and diseases or deaths can be demonstrated through sequential programming systems such as the one presented in this work or through machine learning processes as mentioned in the previous section.

Ultimately, technology and recent advances in computing and data management provide sufficient tools to control animal populations efficiently, sustainably, and responsibly. All these innovations and research demonstrate the potential of new problem-solving approaches: machine learning, artificial intelligence, etc.

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