Sheep Movement Tracking for Early Detection of Anomalies

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May 22, 2024

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Presenter Background

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- Third year student of a double degree in Pure Mathematics and Computer Science at USFQ, Quito, Ecuador.
- Research Assistant at KAPAK: An online platform dedicated to calculate corruption risk indicators in public procurement through the use of AI and data.
- Intern at USFQ Press: Provide logistical support for book publications and articles while also contributing to the management of databases containing recent articles and publications.
- Treasurer of IEEE Computer Society of IEEE Ecuador Section.
- Passionate about the applications of mathematics and computer science to develop solutions that can help others.

Introduction

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The livestock industry is a key pillar of many economies. Efficient health control techniques are essential for ensuring the well-being of animals and early detection of diseases and abnormalities. Timely detection is critical for effective resource management and preventing significant losses for farmers. Therefore, there is an urgent need to develop mechanisms for controlling and detecting anomalies in animal populations early.

Animal behavior analysis has become essential in wildlife management and agriculture, particularly in herding. Early detection of illnesses, roaming predators, or insufficient nutrition in remote herds, based on satellite-positioned movement data, is desirable for livestock owners. This necessitates tracking animals, employing machine learning to analyze regular movement, training custom models to capture movement patterns, and detecting anomalies, such as irregular movement, over short and long periods, such as a full day.

Problem Setting

Problem Setting

There is an urgent need for mechanisms to monitor, detect and interpret anomalies in sheep populations.

Figure: A Valais Blacknose sheep, a breed native to Switzerland, known for its distinctive appearance and friendly nature.

Objectives

Objectives

- **Main Objective:**

  Develop and implement a system for early detection of anomalies in sheep movement behavior to provide a tool to improve health management and prevent significant losses in the livestock industry.

- **Specific Objectives:**
  - Analyze sheep movement data to identify patterns indicative of health issues such as deaths, or flock abandonments.
  - Create a simulation environment to test and validate the effectiveness of the anomaly detection methods using real-time position data.
  - Explore the movements of sheep in a simulated environment to determine key elements to characterize different movement patterns that allow characterizing the health status of individuals.

Background and Related Work

Background and Related Work

Past research highlights the relationship between behavior patterns and animal health:

D. R. Arney (2009) states that stress in the individual could be observed in changes in their usual behavior, such as less time ruminating or less movement.

In recent years, the number of works that use techniques such as machine learning to detect specific anomalies has increased:

W. Khan, et al. (2020) worked with collar accelerometers to identify grazing, walking, scratching, and inactivity (standing, resting).

J. Miltsch, et al. (2018) worked with a triaxial accelerometer and gyroscope sensor on the classification of important behaviors in sheep such as lying, standing and walking.

Solution approach

Simulated Environment

At a fundamental level, the main component of the work was the sheep movement simulator and its group interaction.

- PyGame and Tkinter were used for the graphical interface.
- Three classes were defined: Sheep, Wolf, and Hole.
- Boids model was used to simulate the interaction between sheep and the environment (three components: cohesion, alignment, and separation).
- Sheep movement is simulated as particles move following Newton's Laws in the vacuum.
- Every sheep is identified by a tag composed of a 3-digit number and the word 'ah'. Ex: 750ah.
- Wolfs appear randomly and scare sheeps as they are near to them. If a wolf is extremely near a sheep, it can kill it.
- Colors are used to specify if a sheep is dead, scared, out of the protected zone or stuck in a hole.

Additional Features

- Messages in the console are displayed during the execution of the simulation to announce if a sheep is out of the protected zone or to remark if it is dead.
- After each simulation, images of the track of each sheep are generated.
- Beta: there is also the possibility to load a previous state. It only recovers sheep positions.

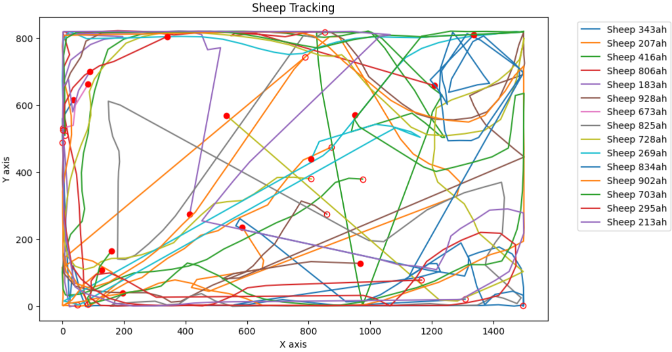


Figure: An example of a track image generated by the program

Death detection method

The method employed is relatively simple.

Recording positions

A position matrix $M \in M_{n \times l}$ 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.

Death detection method

No movement

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

Limitations

- Although the Boids model indeed provides a striking simulation of the behavior of sheep, it is not totally accurate, as it does not consider factors such as age, climate, health status, etc. This is a simple behavior based on the distance between sheep and wolves.
- The modeling of movement inspired by the movement of particles with acceleration in space also has weaknesses. It is not true that living beings always move in response to a constant perpetual acceleration.
- The death detection method scales with difficulty, as it examines a considerable number of distances and iterations. It is clear that its precision is high, but it will not always be an effective method.

Clearly, the chosen method has limitations in terms of effectiveness. 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 other approaches as machine learning.

Demo

Demo

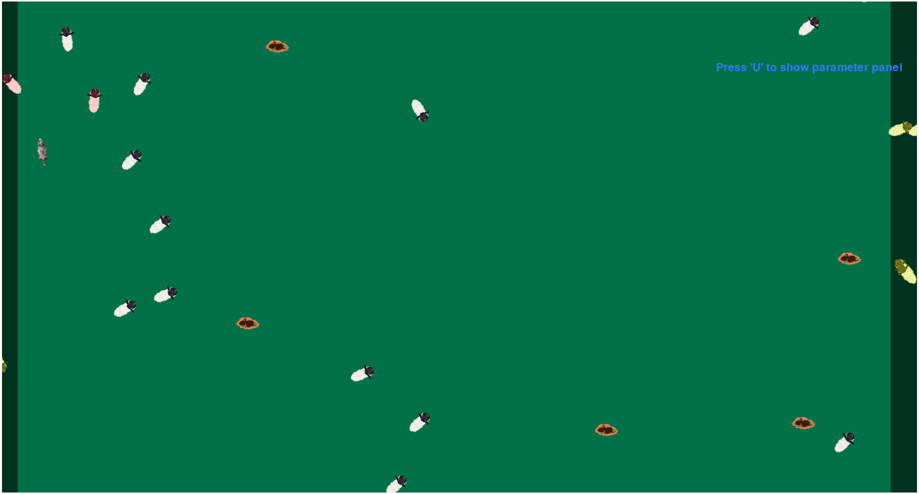


Figure: A screenshot of the simulator running.

Conclusion

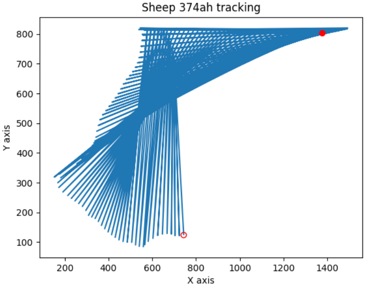
Conclusion

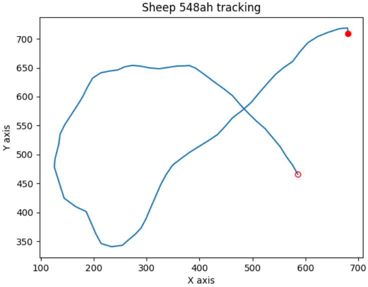
- Monitoring and early detection of strange behaviours and anomalies in sheep activity are crucial topics for the modern livestock industry. The information provided by automated behaviour tracking systems is vital for effective decision-making in herd care. These early and accurate decisions help prevent losses and excessive resource wastage.
- Sensor-based controls provide a real and powerful mechanism for monitoring animal behaviours, which can translate into early detection of all kinds of anomalies. The correlation between these special behaviours and diseases or deaths can be demonstrated through sequential programming systems such as the one presented in this work or through machine learning processes.
- Technology and recent advances in computing and data management provide sufficient tools to control animals populations efficiently, sustainably, and resopnsibly. All these innovations and research demonstrate the potential of new problem-solving approaches: machine learning, AI, etc.

Prospect

Prospect

The tracking images generated with the program, or generated with real sheep data, could be used to train machine learning models that detect anomalies by reviewing the tracking images.





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Thank you!