Modeling Water Buffalo Movement

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As the number of wild Water Buffaloes diminishes, understanding their movement patterns and behavior is becoming increasingly imperative. As a herd animal whose movement relies heavily on its environment, the water buffalo has unique characteristics that make it interesting to model. By modeling water buffalo movement, we are able to better understand their behavior which will in turn help us with preservation efforts for both Water Buffalo and similar species as well. Previous research tracks water buffalo movement but does not use their patterns to create a model. Through building a model, we are able to capture how water buffalo move to find resources (water) when a predator is present. Our results showed that water buffalo moved more in the dry season and less in the wet season. During the wet season they chose habitats near large bodies of water, while in the dry season they settled for small bodies of water like rivers. The model also reproduced accurate herd movements when a predator is nearby.

Introduction

Understanding how animals navigate their environment has always been a popular topic of research. Most animals must manage to collect resources while avoiding predators and protecting their offspring. Of all species, water buffalo are particularly interesting due to their dependence on the environment. Water buffaloes have different movements in the wet and dry season due to changes in the amount of water in their environment. Additionally, since water buffalo are herd animals, their movement poses a unique challenge to model. By modeling movements of water buffalo in the wet and dry season, we are not only able to better understand them as a species, but also help preserve them and other similar species. Also, with a changing climate, we are able to observe how these animals adapt to drastic changes to their environment.

Background and Related Work

One paper by Roug et al uses trackers to monitor movements of water buffalo. The paper measures movement during the wet and dry seasons and compares the two. The data from this paper indicates that during the wet season the buffalos moved less toward larger bodies of water and during the dry season moved more to find smaller bodies of water like rivers. Using the data from this paper, we were able to create a realistic environment for our simulation. Although we were unable to find raw movement data for water buffaloes, this paper captured their own data and reported their findings (*1*).

We haven't found any other simulations of water buffalo movement, so this may be the first one. One other paper both measures and analyzes how water buffalo do different activities such as grazing, standing, wallowing, lying, and drinking. As described in the paper, "In this study, the tools of social network analysis are used to analyze, detect, and depict the proximity patterns in water buffaloes' activities on pasture and the effect of their age and gender on them"

(*2*). Although this is somewhat useful, we are more interested in the specific activity of moving and modeling it in a realistic environment. Both of these papers give important insights into how water buffalo move and what their environment looks like.

Methods

The main method to create the buffalo herd used an approach similar to the flocking simulation as described in class. The herd has about 400 agents, and at each time step each agent's new position and velocity is calculated and updated. The agents are all attracted to each other and water sources, and are repelled by the predator in the simulation. So as an agent approaches the predator it will be repelled and as an agent approaches water it will be attracted. By using this approach we are able to simulate how the buffalo move to find resources when a predator is present. To create water sources, we created static agents that do not move but still attract agents of the herd. The predator is controlled by the user running the program, and this way you are able to see in real time how the herd reacts to the predator's movements. At the beginning of the simulation, the position and velocity of the herd is randomized to make the simulation more realistic and dynamic. In addition, at each time step there is an element of randomness in the position and velocity to create a more realistic simulation. This way the buffaloes move in a more unpredictable manner as opposed to moving in a straight line when no attracting or repelling agents are present. To simulate the different seasons, we created two different environments; One for the dry season and one for the wet season. The dry season environment contained less large bodies of water and more smaller bodies like rivers. On the other hand, the wet season contained more large bodies of water and less small bodies of water. By creating a realistic difference in the environment during both seasons, we are able to capture more accurate and meaningful results from the simulation.

To capture data from our simulation, we measured both the distance moved by buffalo by time step and cumulative distance traveled throughout the simulation. Both of these data points were captured for both the wet season and the dry season. (add more info on how charts and graphs were created here)

Results

Our results are depicted in the graphs below. During the wet season the buffalo had both more distance moved per time step and more cumulative distance moved than the dry season. As expected, the opposite was true for the dry season as both data points measured were less than the wet season. Also as expected, in both cases the buffalo herd moved away from the predatory and toward the water sources. Since the predator repelled the herd more than they were attracted to the water, the herd moved away from the water as the predator got closer. All of these results are in line with what we expected and also match data from our research. (add more/better explanation for graphs include graphs here)

Conclusion

This report shows how the movement of water buffalo changes both in the dry and wet seasons and with a predator present. Previous research from tracking data showed that water buffalo move less in the wet season and more in the dry season. Additionally, previous research showed that water buffalo move more in the dry season and find smaller bodies of water and move less in the wet season and find larger bodies of water. By creating an accurate model, we were able to show both of these insights to be true. Modeling animal habitat selection is becoming increasingly important, and especially with animals reliant on their environment. Drastic changes in the climate can affect these species directly, and understanding their movement patterns can help us with preservation efforts. Not only will this work help protect water buffaloes, but it will help other species as well.

References and Notes

1. Roug, A., Muse, E.A., Clifford, D.L. et al. *Seasonal movements and habitat use of African buffalo in Ruaha National Park, Tanzania.* BMC Ecol 20, 6 (2020).

2. Tsiobani, E. T., Yiakoulaki, M. D., Hasanagas, N. D., & Antoniou, I. E. (2020). *Proximity patterns in water buffaloes' activities on pasture.* Archives animal breeding, 63(1), 19–29. https://doi.org/10.5194/aab-63-19-2020

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```
However, this record of the solar nebula may have been
partly erased by the complex history of the meteorite
parent bodies, which includes collision-induced shock,
thermal metamorphism, and aqueous alteration
({\it 1, 2, 5--7\/}).
```

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\begin{enumerate}
\item G. Gamow, {\it The Constitution of Atomic Nuclei
and Radioactivity\/} (Oxford Univ. Press, New York, 1931).
\item W. Heisenberg and W. Pauli, {\it Zeitschr.\ f.\
Physik\/} {\bf 56}, 1 (1929).
\end{enumerate}
```

yielding

References and Notes

1. G. Gamow, *The Constitution of Atomic Nuclei and Radioactivity* (Oxford Univ. Press, New York, 1931).
2. W. Heisenberg and W. Pauli, *Zeitschr. f. Physik* **56**, 1 (1929).

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Acknowledgments

Include acknowledgments of funding, any patents pending, where raw data for the paper are deposited, etc.

Supplementary materials

Materials and Methods

Supplementary Text

Figs. S1 to S3

Tables S1 to S4

References *(4-10)*

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