Precision Livestock Farming Using Engineering Strategies in Swine Barns

In this research proposal, I propose using emerging sensor technologies, flexible electronics, edge computing capacity, computer vision, and artificial intelligence to facilitate swine farming.

Conclusion:

Intellectual Merit: Develop novel sensing technologies tailored for the challenges of swine farming environments. Establish correlations between various physiological and behavioral indicators (water consumption, foot patterns, vulva changes) and important production factors such as estrous timing and overall health. Create a comprehensive, high-quality public dataset that will serve as a valuable resource for the broader agricultural and computer vision research communities. Advance the application of artificial intelligence and machine learning in livestock farming through the integration of multi-modal data sources. Enhance our understanding of swine behavior and welfare through non-invasive, continuous monitoring techniques.

Broader Impacts: Improved animal welfare through early detection of health issues and more precise management of breeding cycles. Enhanced sustainability in livestock farming by optimizing resource use and improving production efficiency. Advancement of sensor technologies and data analysis techniques that could be applied to other areas of agriculture. Creation of a public dataset that will accelerate research and innovation in agricultural computer vision and AI applications.

Potential for significant economic benefits to farmers through increased productivity and reduced labor costs. Contribution to food security by improving the efficiency and reliability of pork production.

Perspective 1: Implementation of Ultrasonic Water Sensors for Precision Livestock Farming (PLF)

Intellectual Merit: Common pressure based water meters in barns may provide information on the total water consumed, but they lack the precision to measure the low water flow rate. The objective of this research is to develop or implement a novel commercial system, such as a water meter based on Ultrasound (1), that the accuracy would not affect by pressure difference, to accurately measure the level and frequency of water consumption by each pig.

Broader Impacts: Dr. Mike Brumm, retired Extension Swine Specialist at the University of Nebraska, found that monitoring daily water use in individual groups of pigs can provide information to aid in predicting pig performance (2). However no detailed research in recent years has been published on the impact of the water intake on swine health and production efficiency, particularly in terms of estrous timing. This study would be groundbreaking in exploring the relationship between water drinking and swine estrous timing and behavior monitoring.

Perspective 2: Flexible Sensor Electronics to Detect the Foot Pattern on Floor

The flexible sensor electronics system would consist of a network of pressure sensors embedded in a flexible substrate. The sensors would be connected to a data acquisition system that would record and transmit the data to the cloud which would then process the data to extract the foot pattern of the swine. The foot pattern of swine can be influenced by a variety of factors, including the animal's age, weight, health, and environment. By tracking the foot pattern over time, farmers can identify changes that may be indicative of a health problem or a change in the animal's environment.

Intellectual Merit: Develop a novel flexible sensor electronics system that can be placed under the floor to detect the foot pattern of swine. Investigate the relationship between the foot pattern and the physiological and behavioral changes of swine. Explore the potential applications of the sensor system in swine production, such as early detection of estrous, monitoring of lameness, and assessment of welfare.

Broader Impacts: Research to advance sensor technology applications in agriculture, and to determine foot pattern relations with a variety of factors, in order to have a finding in this unique scientific topic in agriculture.

Perspective 3: Robotic arm for close-up capture of swine vulva changes

Intellectual Merit: Vulva swelling and reddening are signs of approaching estrus(3). A robotic arm would address the limitations of traditional static computer cameras fixed in one position. As animals move and change posture, the robotic arm can be trained to find optimal angles for capturing vulva size. This approach can then facilitate model predictions based on clear, high-quality images.

Broader Impacts: This robotic capture system for livestock farming can provide a more efficient way to gather valid information, leading to higher precision in predicting estrus.

Perspective 4: High-Resolution Computer Vision System and Public Dataset

Intellectual Merit: In agricultural engineering, the public computer vision dataset is relatively limited (4). We aim to expand activities in swine farming. This research will enhance the publicly available dataset in the swine farming sector by capturing both gestational stall, free feeding, activity patterns in farrowing, and permegant. Up to 20 million high-resolution portable cameras, such as the Flair serious (5), and adding the IR light module will enable us to create a high-resolution dataset from a light-limited research environment for various tasks.

Broader Impact: The public dataset will offer significant potential for the broader community to train large vision language models. By customizing our approach to obtain high-quality data in dark environments, we will provide an uninterrupted and continuous dataset for training better artificial intelligence models.\

Perspective 5: Cross-modality data for behavior and health monitoring, and scientific advancement

While single data sources provide valuable insights, integrating multiple modalities can unlock a more nuanced and holistic understanding of livestock behavior, health

Intellectual Merit: Traditional monitoring systems often rely on single data sources, which can limit the depth and accuracy of insights gained. By transitioning from single to multiple data sources, this project aims to construct a robust data network that captures diverse aspects of the farm ecosystem.

Broader Impact: Understanding animal behavior through comprehensive data allows for the creation of more enriched and comfortable living environments. Automated and precise monitoring reduces labor costs associated with manual inspections and mitigates losses from undetected health issues or suboptimal breeding.

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2. (2) University of Minnesota Extension. (2018). Keeping track of water intake to monitor pig performance. Retrieved from https://extension.umn.edu/swine-nutrition/using-water-intake-monitor-pig-performance
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