**Understanding sow’s mothering ability by analyzing their behavioral phenotypes from overhead sensor images**

UCARE Applicant: Ahlam Al Kiyumi, Biological Systems Engineering

1. **STATEMENT OF PURPOSE**

The purpose of this research is to collect and analyze sequential overhead images in a swine barn to help elucidate sows’ mothering ability. Pre-weaning mortality has detrimental effects on piglet well-being, worker morale and economic returns to U.S. pork producers. An average 17.8% of the piglets born are lost before weaning (Stalder, 2018), half of these piglets are lost due to crushing by the sow (Lay et al., 2002; USDA, 2012). The swine industry has used farrowing crates to protect piglets by restraining the sow’s movements and providing a separate safe space for them. Unfortunately, even within the farrowing crate systems, piglet crushing still occurs and a considerable litter-to-litter variation in the incidence of piglet crushing is observed. It is known that crushing of piglets occurs during sow postural transitions, mainly from standing to lying or when a sow rolls from side to side. However, little progress has been made in the past few decades in understanding if there are any variation in the behaviors or behavioral sequences between sows with high and low piglet crushing rates. This research will provide us important and quantified information to understand sows’ behavior to improve piglet pre-weaning survival rates.

1. **RESEARCH QUESTION**

Breeding sows with better mothering ability is critical. We **hypothesize** that there are differences existed in sows’ behavior which relate with their mothering ability and piglet crushing rates. For example, we think sows who spend more time looking side to side and checking piglets before sitting or lying have a lower piglet mortality rate and better mothering ability compared with sows who spend little time checking for piglets before postural transitions. One of the **challenges** of this research question is that we cannot evaluate sow’s mothering ability only based on the numbers of piglet death since piglet death is a complex problem involving both piglet health conditions and sow’s mothering ability. With the image steam from an overhead sensor suit, we can automatically monitor the sows’ behavior while minimize the sensor contamination in the harsh environment. Hence, in this study, our **objective** is to identify a series of sows’ postures that are potentially related with their mothering ability from the overhead digital and depth images collected in a swine barn over the pre-weaning period, and analyze the time difference of each posture between the sows with high and low piglet mortality rates.

A series of potential behaviors from depth images using state-of-the-art machine learning models that are possibly the key phenotypes related with sow’s mothering ability and pre-weaning piglet mortality rate. The potential behaviors include standing, eating, drinking, backing up to the rear of the crate and look around to check piglets, looking down to find piglets underneath, keeling, lying on belly, lying on side, rolling and sitting.

1. **SIGNIFICANCE OF THE RESEARCH**

United States is the world’s third-largest pork producing country and one of the largest pork exporters. Preweaning mortality has detrimental effects on piglet well-being, worker morale and economic returns to U.S. pork producers. Breeding for sows with better mothering ability and low piglet crushing rates is a fundamental solution to this issue. This project will be the first step to explore and understand sow’s behavior related to their mothering ability and lead to a better genetic selection for sows. We will also share the final results of the project through various ways as mentioned in detail in the last section of this proposal. after we have the data and tests made.

1. **METHODS OF DATA COLLECTION**

Overhead images will be collected with the state-of-the-art behavior monitoring system at USDA-MARC farrowing room located in Clay Center, Nebraska. Above each farrowing stall, a time-of-flight depth sensor (Kinect v.2, Microsoft, Seattle, WA) is mounted with the lens aimed at the stall. This sensor simultaneously takes digital images and depth images which measure the distance between the camera and the surroundings. Each sensor is connected via USB to a mini-PC to store the image data. We will collect images every 5 seconds in three rooms of 20 farrowing crates over the pre-weaning period.

1. **METHODS OF DATA ANALYSIS**

**5.1 Label behaviors in the digital and depth image pairs**

I will modify an existing MATLAB code to display the digital and depth images and label them with the sow’s behavior. For example, sows have six-movement transitions (lying on the right/left side, kneeling, lying on the belly, standing, sitting) and four postural activities (eating, drinking, looking side to side, walking back and forth) and we will use -none- if the sow doesn’t do anything. All labeling files will be saved as an Excel file. This first step is the important step and will take efforts in this research. It is estimated that there will be a big data generated and it takes around 12 seconds to display and label each individual image pair. If I take 12 seconds in each frame means: 5 depth images in a minute and (5\*60= 300) depth images in an hour, (300\*10 = 3000) depth images in 10 hours/week. For the first 13 weeks from September 2021 till the end of the fall semester 3000\*13=39000 depth images which will be an approximation of high and low mortality depth images.

**5.2 Calculate the behavioral time budget of each sow in a day**

After labeling the images with sow’s behaviors, the next step will be to analyze the time budget or the total amount of time a sow spent for each posture or behavior. The time between each transition will be various from sow to another and in our view, it will differ from sows with low piglets mortality and the sows’ with high piglets mortality. I will develop a MATLAB code to extract the labeled depth images and calculate the time in each behavior/posture. Having the time measured will allow us to see how the sow behaves and is it different from one another.

**5.3 Statistical test for behavioral difference between sows with high and low piglet mortality rates**

Once we have the time budget of each behavior/posture, the next step will be to see if there exists a significant difference of each behavior/posture between sows with high and low piglet mortality using the classical t-test. A t-test is a type of inferential statistic used to determine if there is a significant difference between the means of two groups, which may be related in certain features. I expect the t-test to produce two values as its output: t-value and degrees of freedom. The t-values is a ratio of the differences between the mean of the two sample sets and the variation that exists within the sample sets. Higher values of the t-value, also called t-score, indicate that a large difference exists between the two sample sets. The smaller the t-value, the more similarity exists between the two sample sets.

With the statistical analysis, we will have a clear idea about sow’s behavior and how this affect piglet mortality which will help us to identify the difference exists in sows’ behavior related to their mothering ability.

**5.4 Develop machine learning algorithm to automatically identify sow’s behavior**

To automate this process for future research, I will learn and develop a machine learning model in MATLAB to automatically identify sow’s behavior. The behavior labelled in 5.1 will be used to train the model and to test the model performance. The deep learning and image processing toolboxes in MATLAB will be used. This developed model will help the analysis of the massive data collected in the future for the sow’s behavior analysis research.

1. **BENCHMARKS AND OUTCOMES**

Starting from September 2020 till the dead week of the fall 2020 semester, I will work on sorting the images with manually logged piglet mortality rates and labeling the images. This will one of the major efforts in this research. At the same time, I will start learning the machine learning using MATLAB and its tutorial to develop an automatic way to label the images for future research by working with my advisor Dr. Yeyin Shi and other members in the group. From the beginning of spring 2021, I will analyze the time budget of each behavior and perform the statistical tests to investigate the differences of behaviors between the sows with low and high piglet mortality rates. I will also start implementing the machine learning algorithm. Starting in March 2021, I will work on a research paper about the final result we get to share it to the science community. In addition, I will attend at least one skill-building seminar and one red talk. Also, I planned with my advisor Dr. Yeyin Shi in Biological Systems Engineering to present the research at national conference or at Undergraduate Poster Session. At the end of this UCARE program, I will upload all the final research products to the Digital Commons.