Michigan State University
College of Engineering; Dept. of Electrical and Computer Eng.
ECE 480 Capstone Design Course Project Charter

Pig-O-Vision System

Sponsoring Company/ Organization:
Michigan Pork Producers Assoc. and MSU CVM and LCS
Contact Information:
Name: Dr. Madonna Gemus Benjamin
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Phone and Best Time of Day to Call: 517-614-8875: 7am to 6 pm

Background Information: Developing and utilizing a visual imaging system to assist Michigan pork producers in evaluation of cull sow body condition and weight.

Business Case:

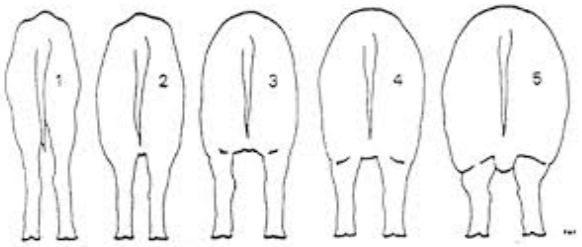
- Accurate sow body condition scores (BCS) and sow weight can enable producers to adjust the amount of gestation feed in order to replenish or maintain body reserves in sows. There is also a correlation between BCS and welfare considerations such as early culling, lameness and shoulder sores.
- Current body condition measures available in the swine industry are either subjective (visual body condition scoring) and are generally influenced by internal overall herd scores ***or*** are quantifiable using the constructs of shape and size, lean and fat ratios. Current quantifiable methods require that sows are restrained long enough to acquire a reading and data capture is not automated.
- There are ever increasing requirements by swine producers to demonstrate assurances of improved swine welfare.
- Michigan State University Extension works closely with the swine industry to ascertain gaps and provide operative solutions to all swine producers.
- To our knowledge there is not yet a tool of this scope in the marketplace.
- We are collaborating with Dr. Mark Knauer who has developed a handheld caliper, which measures angularity and shape of the sow as she gains or loses weight. We expect that there might be a patent derived from this image based software, yet we plan that the product will be accessible to all producers.

Project Intellectual Property Considerations:

- Will the student Design Team be required to sign a Non-Disclosure Agreement? No
- Will the student Design Team be working with technology contained in pending patents not yet granted? No.

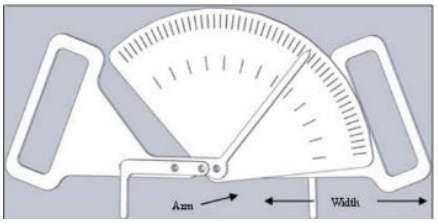
Opportunity Statement:

Figure 1. Visual Body Condition Scoring.

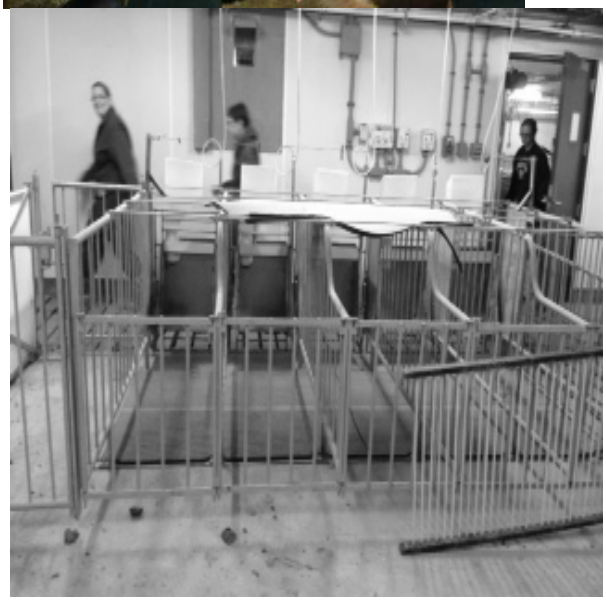


Body condition measures available in the swine industry include: a sow caliper (KSC), sow weight (WT), 10th rib backfat (BF), 10th rib LM area (LMA) and visual body condition score (vBCS) which scored on a 1 to 5 scale by a technician. The vBCS teaching tool used to instruct producers enrolled in PQA Plus is a simple diagram (Figure 1), is a visual BCS based on a scale of 1 to 5, with 1 = very thin, and 5 = very fat. While most evaluators are able to discern a 1 and 5 score, body condition scores 2, 3 and 4 have not been consistently identified. Due to the subjective nature, the scores assigned are generally influenced by overall scores of the herd (Clowes et al., 2003). In other words, in a thin herd, a low body condition score can be interpreted as normal.

The KCS, is a handheld caliper system developed by Dr. Mark Knauer. The KCS, which measures the angularity of the sows' back (M. T. Knauer, D. J. Baitinger, 2015) is based on the premise that as a sow loses muscle and fat, her back becomes more angular. The limitations to KCS is that a good reading requires sows to have limited movement, that human handlers are able to reach over the gestation pen onto the last rib to make the reading and information is captured if scribed. While this method was attainable in individual pen systems, loose sow housing methods require a measurement which allows fast and accurate assessment that can also retain information for data entry and audits.



Our research proposal is motivated by the existing and rapidly growing imaging and motion capabilities using extraction, perimeter shape, and visual imaging to determine the shape, angularity and weight of animals (pigs, fish, goats, sheep, and cows). DeShazer (et. al, 1988) reported over 90 applications for image analysis in pig production. One of the advantages with modern commercial swine is the skin is predominantly white/pink allowing for great contrast with visual imaging.



Presently visual image analysis has been proposed as a method for real-time and continuous monitoring of pig weight (Kashiha et al, 2014) and the locomotion of pigs using image analysis with high accuracy (Kashiha et al, 2014). Based on his validation of the caliper and algorithm, we are collaborating with Dr. Knauer to develop a system or application appropriate ranging system and the automation of data collection.

- Who is the customer?
    - Swine producers (farms) and buyers will be the ultimate customers for this product.
    - M. E. Benjamin and R. Malinowski: Large Animal Clinical Sciences. MSU
    - Michigan Pork Producers Association

Hardware Deliverables:

- Image capture hardware including vision system (camera, LIDAR, etc.) capable of working in ambient lighting in test area (if done in a barn) or in sunshine outdoors, RFID reader, and environmental packaging capable of surviving on a swine farm (manure, rodent infestation, strong ammonia atmosphere (corrosive), washed down periodically, dusty in the summer, used outdoors in the sun)
- Image capture has two components: (1) Image taken of a sow on the move as if she were standing still to generate estimations of body weight and determine BCS, (2) detection of the degree of 'waddling' side-to-side as she is passing thru the chute. Waddling is an indication of lameness, or illness, in the sow. Data analysis will be done by a Vet School Post Doc in summer 2017.
- Test chute with sensors and computer monitoring systems attached and appropriately protected from 400 - 600 pound swine ramming into it when excited and on the move
- Final written and oral Report demonstrating a working system on Design Day
- All documents, hardware, source code, and project working notes delivered to M. Benjamin at the end of the semester

Computer System Deliverables:

- Measurement Computer System and User Friendly Human Interface housed in an enclosure capable of surviving on a swine farm (manure, rodent infestation, ammonia atmosphere, washed down periodically, dusty in the summer, used outdoors in the sun)
- Data base capable of measuring and monitoring 10,000 sows over three points within each parity (this requirement is to be refined by Dr. M. Benjamin at the start of the semester)
- Data Analysis to report BCS by sow ID in (1) a raw data dump to be used in off-line statistical software packages such as Excel and (2) statistical analysis to drive the User Interface Reporting (analysis requirements to be defined and refined by M. Benjamin at the start of the semester)
- Data analysis to report estimation of sow weight based on image – weight cells will not be used. (M. Benjamin has literature showing how this is currently done in pigs and cattle)
- Ability to generate distribution plots of sow weight and BCS (1 to 5) by sow ID
- Final written and oral Report demonstrating a working system on Design Day

- All documents, hardware, source code, and project working notes delivered to M. Benjamin at the end of the semester

Goals:

- Goals should be SMART
    - **Specific** – a convenient, non-invasive, welfare friendly, sustainable and economically viable method to collect images, extract sow shapes, length and weight in sows ranging from 350 to 600 lbs moving from an unconstrained area (wide alley) and will walk through a pen or chute at varying heights and walk at different speeds – sometimes at a trot, depending handler techniques and on sow reluctance. Animal identification will use RFID tags
    - **Measurable** – Housing of equipment for top-view, side-view, or background subtraction method is required to accurately obtain individual sow shape and weight to over 90% detection rate. Cameras (ie Go Pro, Quickcam) must allow for gradual light changes, capacity and stability to measure individually, up to 30 sows per day and the capability to withstand caustic atmospheres such as rodent infestation, corrosives such ammonia, manure and urine and dust. If using a chute system the cameras and equipment must be housed in a dust and moisture, and pressure washer, proof container. Each sow will be measured at 3 points within each parity (wean, breed and farrow).
    - **Attainable** – Students will visit the MSU Swine Farm in the first week of the project. Drs. Benjamin, Malinowski or Ison will meet students on a weekly basis.
    - **Relevant** Limited to this design challenge.
    - **Time Bound** – complete working system delivered to M. Benjamin in the 13 week working semester.

Hardware Scope:

In Scope:

- Construction of a measurement chute capable of withstanding 400 - 600 pound pigs running into it
- Identification and procurement of appropriate imaging system, vision system, or measurement system to detect the sow's length, width and hindquarter profile shape. (This will be further defined by M. Benjamin the first week of the semester)
- Sensor to read the sow's RFID identification tag on her ear. Note: Tags will be randomly oriented based on how the tag was attached and position of head and ear
- Installation (attachment, wiring, environmental proofing) of all sensors to the measurement computer system

Computer System Scope:

In Scope:

- Measurement Computer System – all elements such as Processor, Memory, power supply, Data Base, and Human User Interface, etc.
- Measurement Computer System housed in rugged enclosure capable of surviving on a swine farm
- User interface screen and controls
- Data Reporting – raw data dump capabilities for off-system analysis capable of being used with Excel.
- Data Analysis – Scatter plot of sow BCS versus sow ID; Statistical Mean of test group of swine BCS

Constraints:

- Design and construction of the prototype system will be done at MSU, but proof of a working system will be done with live sows at a pork producer 1 to 2.5 hour drive from MSU (depending upon which producer is selected for the trial). Proof of a working system will require several trips to the pork producer to test the system and gather data; and therefore the student team will have to have transportation available to them.
- Students must be willing to shower in and out and change clothes in and out of a Swine Farm. Thus each visit to the farm will require several hours to all day.

Project Team: (Completed once semester begins)

Name	Responsibility

Faculty Advisor: (Assigned by ECE Dept. based on project requirements)

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