

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

**Team 9: Characterizing Sow Locomotion using Kinect
Depth Sensor Data**

Sponsoring Company/ Organization: Michigan State University, College of Veterinary Medicine

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Background Information:

Machine vision is a well-established technology in industrial applications such as automated inspection, and especially after the came out of relatively inexpensive 3D image sensors which are opening doors for many new vision applications. Depth perception is empowering new vision opportunities in smartphone apps, industrial automation and robotics areas. In this project we want to build a 3D environment/body perception system using Microsoft Kinect to characterize sow locomotion, which will bring the 3D perception technique into both traditional farming and recent smart agriculture.

Precision Livestock Farming (PLF) is a unique bridging of engineering tools and real world situations to improve animal welfare and livestock productivity. Agriculture has advanced considerably in recent decades, but only in the last few years has PLF been investigated, and there are, as yet, very few examples where PLF has reached the stage of on-farm application [1]. PLF is defined as “*the management of livestock production using the principles and technology of process engineering to monitor, model and manage animal production*” [2]. Reasons for this lack of implementation include the cost and complexity of the technology, and, ultimately, much more research is required. This will need close collaboration between biologists, engineers, and technology companies to produce an end product suitable for on-farm use.

The person responsible for care and productivity of livestock is the stockperson. Another concern regarding the automation of livestock production, is an ethical one, with mechanical automation replacing human care. However, there are several opportunities for PLF to complement stockperson animal care, using computation to detect sensitive changes across time, and to monitor a large number of animals,

alongside other on-farm data, which could help maximize herd health, welfare, and productivity.

One case where PLF could assist the stockperson, with regard to health monitoring, and to assist with audit requirements, is the detection of lameness or locomotor disorders in breeding pigs (or sows). Lameness is a major concern in pork production, reducing sow longevity, productivity, resulting in early removal of sows from the breeding herd, as well as being a major welfare issue, as lameness is an indicator of pain [3]. Creating a tool for automating detection and scoring of locomotor disorders, could assist the stockperson in housing, management, and treatment decisions for individual sows. It could also assist by long-term monitoring of lameness progression, and changes across time to help identify on-farm risk factors (e.g. sow housing management, genetics, or nutrition) relating to lameness issues, helping reduce the problem on sow production units.

A previous capstone project developed a system to record the shape of sows using a Microsoft Kinect depth sensor, mounted directly above the sow, along with associated software to characterize the shape of the sow. The current project aims to use a similar approach, using video images already collected, to develop computer vision based algorithms to characterize the locomotion or movement of sows. Therefore, this project is more directed towards algorithms and coding, and would suit students with a strong interest in computer programming or willing to work in the computer vision industry. Working from Microsoft Kinect depth video images, the outcome will be to create algorithms to convert these images into an objective score/measurement based on sow movement features.

Business Case:

In fall 2009, Michigan passed legislation (Public Act 117) that amended the Animal Industries Act (Michigan Public Act 488 of 1988) to prevent housing gestating (or pregnant) sows in individual stalls, which severely restrict sow movement. Therefore, in Michigan, sow gestation stalls will be eliminated when this new legislation is set to become law by April 1, 2020. This will lead to all sows in Michigan being housed in group pens with other sows for the majority of their pregnancy. Group housing allow sows freedom of movement and the ability to socially interact with other sows. However, some of this social interaction can be negative, with aggressive interactions potentially resulting in injuries, including lameness [4].

Sows are moved between building/barns or rooms on the farm at several stages of production, for example between the building/room in which they are housed for giving birth and nursing their piglets, to the location they are housed in for breeding and gestation. The premise of using a Kinect depth sensor to measure sow shape, was to locate the sensor in a corridor or alleyway between these locations to automatically record the sows when they are moved as part of normal farm practice. Farmers and stockpersons or caretakers are under significant time pressure, so the device aims to require low or no input to collect the data, but provide an advantage

with the ability to monitor changes in sow locomotion as farms transition to new housing systems, as well as make small changes to improve these new systems. The hard/soft-ware also needs to be low cost, since pork producers' work on tight profit margins, which is another reason why wider-scale PLF has not reached the implementation stage. As technology is advancing rapidly, particularly in the computer vision industry (estimated to reach 33.3 billion market size in 2019), this is driving down costs, and enabling other industry sectors, like the livestock industry, to utilize this technology.

Project Intellectual Property Considerations:

- Will the student Design Team be required to sign a Non-Disclosure Agreement? **No.**
- Will the Design Team be able to post their work on the course web site? **Yes.**
- Will the student Design Team be working with technology contained in pending patents not yet granted? **No.**
- Can the electronic design be shown, but the embedded software protected? **Yes.**

Opportunity Statement:

There are companies (for example: <https://www.zinpro.com/lameness/swine>) with an interest in this topic, and may have technology under development. However, at MSU, we are working directly with farms, combining expertise from Veterinary, Animal Science, and Engineering to maximize the opportunities of visual imaging using low-cost technology. Pork producers in Michigan could potentially benefit at this time, due to the significant changes in the housing and management of sows in the coming years. Combining the characterization of sow locomotion/movement with other data recorded on-farm opens up the potential to make changes of economic benefit to the producer, as well as benefiting the sow with welfare improvements.

The feasibility of this project within the capstone time frame is possible as video images are already available to begin programming to characterize features of sow locomotion from Kinect depth sensor data. Additionally, there is also the opportunity to collect further data at the MSU swine farm, perhaps from different angles or perspectives to improve data capture and processing capabilities. The team will also be given the opportunity to visit the swine farm and learn more about the pork production industry. As global population and subsequent food demands increase, PLF is set to be a growth area in coming years, with potential opportunity, and a great need for engineering expertise.

Deliverables:

- 1) The team is expected to meet weekly with sponsors Dr. Benjamin and Dr. Song.
- 2) A brief literature review outlining existing imaging technologies used to characterize sow or animal locomotion in a research setting, and provide ideas for adapting these principles for on-farm implementation (e.g. [5]).

- 3) Create algorithms (using available coding language, e.g. C++, C#, .NET and Matlab) of already collected Kinect depth video to characterize normal sow locomotion and posture based on features of sow movement established during part 1).
- 4) Potential to collect further on-farm data if needed, from different angles, using two sensors, or with markers on the sow to optimize or test these algorithms.

Goals:

By the end of the semester, success for us would be to have a coded algorithm to convert Kinect depth video images into an objective score of a movement feature/features to be compared between multiple sows. For example, measuring sow “swagger” or the sideways rotation angle of a sow as she walks. Students will have access to some color video clips, alongside the Kinect depth data to clearly demonstrate visually how their algorithm measures (a) particular movement feature(s), perhaps by simultaneously showing two sows with differing movement.

Scope:

Due to the nature of the project, we feel that it would suit a small team with a particular interest, and knowledge in computer programming. We would encourage the team to keep it simple and look at easy to record features for this short project, and to avoid an impossible to achieve volume of coding. By conducting a review of the literature at the start of the project, the team should be able to identify simple sow locomotion features, which are easy to record from the Kinect depth sensor images.

Constraints:

The previous capstone team used Matlab as the coding platform, however, we encourage other platforms to be used to enable a wider-use of the code beyond those with a Matlab license.

References:

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<http://www.fao.org/docrep/u7600t/u7600t01.htm>.
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doi:10.1016/j.compag.2008.05.005.
- [3] S.S. Anil, L. Anil, J. Deen, Effect of lameness on sow longevity., *J. Am. Vet. Med. Assoc.* 235 (2009) 734–8. doi:10.2460/javma.235.6.734.
- [4] L.M. Pluym, D. Maes, J. Vangeyte, K. Mertens, J. Baert, S. Van Weyenberg, et al., Development of a system for automatic measurements of force and visual stance variables for objective lameness detection in sows: SowSIS, *Biosyst. Eng.* 116 (2013) 64–74. doi:10.1016/j.biosystemseng.2013.06.009.

- [5] S. Stavrakakis, W. Li, J.H. Guy, G. Morgan, G. Ushaw, G.R. Johnson, et al., Validity of the Microsoft Kinect sensor for assessment of normal walking patterns in pigs, Comput. Electron. Agric. 117 (2015) 1–7.
doi:10.1016/j.compag.2015.07.003.

Project Team: (Completed once semester begins)

Name	Responsibility

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