

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

Team 10: Development of low cost wearable motion sensor system with wireless cellular network for individual sow identification and data transfer.

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

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Background Information:

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. Traditional gathering of information by the stockperson such as written notes is an inaccurate method to share data and has a high probability of human error. 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, is with a cost effective method of animal recognition or identification from a remote location. The control of inputs to outputs requires identification of each unit at each level whether individual, pen, flock or herd. For example, a Radio-frequency identification (RFID) system, battery-powered tags are attached to the tracked animals and sensors are placed in the tracked areas. The tag emits a signal, received by the sensors and is used to calculate a 3D position of the tag. RFID technology is an impressive tool for sensing and tracking the location of objects in real-time. Tracking and identification systems are used in many industries, including low cost RFID stickers placed at airports on individual

luggage. RFID is increasingly applied not only to commercial logistics and distribution but also the livestock industry. These initial systems were structured with a fixed reader, but usability of RFID is now further enhanced through smart phones to read, store and modify the information.

A previous capstone project developed an Arduino RFID tag reader as part of a 3D imaging project of sows. The goal for the low-frequency RFID reader was to signal the camera of the approaching sow and to transfer individual identification to the computer database for analysis. In this prototype MATLAB did not recognize the reader. A copy of the Winter Semester ECE 480 2017 Final Report will be provided to the Capstone Fall Semester ECE 480 2017 team.

The current project aims to use a similar identification approach, such as RFID, sense and identify one or more animals and integrating the use with sow imaging devices to correctly initiate the recording of the image. Therefore, this project is directed towards coding and wireless communication and would suit students with a strong interest in computer programming.

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. Feed access is a major motivation for pigs when they are healthy. Research has shown that sick or injured animals will decrease their feeding time [3, 4]. Tracking sows that have consumed feed or water can be difficult in a group, resulting in undetected injury or illness.

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 gaming industry, 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: <http://www.skiold-acemo.com/en/breeding-equipment-uk>) 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 within 3 years. Radio-frequency identification (RFID) at feeding and drinking can be used to identify occurrence and duration of feeding and drinking behaviour as well as assist in individual identification prior to imaging and 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 RFID and other biosensor programs are already available to begin programming to individually identify sows. The team will also be given the opportunity to visit the MSU 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 identification technologies used to characterize livestock in a research setting, and provide ideas for adapting these principles for on-farm implementation (e.g. [5, 6]).
- 3) Build the wireless communication between RFID reader and online monitoring system (running on a computer). Develop algorithms (using available coding language, e.g. C++) to identify pigs via the signal from the reader of animal activity. Build a database to match the RFID signal with each single sow.
- 4) Potential to collect further on-farm data if needed, and to use dual or more readers to realize multiple objects identification.

Goals:

By the end of the semester, success for us would be to have a coded algorithm RFID system including: (a) a database to match the RFID signal with each single sow; (b) an entire wireless communication function between RFID reader and a computer; (c) a software that runs on a computer to identify each single sow based on the RFID signal received by the RFID reader; (d) an integration of the software mention above to an existing sow body detection system to trigger the image/video capture.

Scope:

Due to the nature of the project, we feel that it would suit a small team with a particular interest, and knowledge in either signal processing or software programming (focus on communication). We would encourage the team to keep it simple and look at easy

methods to record features for this short project, and to avoid an impossible volume of coding. By conducting a review of the literature at the start of the project, the team should be able to identify simple identification programs.

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:

- [1] C.M. Wathes, Precision livestock farming for animal health, welfare and production, in: A. Aland, F. Madec (Eds.), *Sustain. Anim. Prod.*, Wageningen Academic Publishers, 2009: pp. 411–419.
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- [3] S. Stavrakakis, W. Li, J.H. Guy, G. Morgan, G. Ushaw, G.R. Johnson, S.A. Edwards, 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.
- [4] Almeida PE, Weber PS, Burton JL, Zanella AJ. Depressed DHEA and increased sickness response behaviors in lame dairy cows with inflammatory foot lesions. *Domest Anim Endocrinol.* 2008;34(1):89-99. doi:10.1016/j.domaniend.2006.11.006
- [5] Matthews SG, Miller AL, Clapp J, Plötz T, Kyriazakis I. Early detection of health and welfare compromises through automated detection of behavioural changes in pigs. *Vet J.* 2016;217:43-51. doi:10.1016/j.tvjl.2016.09.005.
- [6] Jukan A, Masip-Bruin X, Amla N. Smart Computing and Sensing Technologies for Animal Welfare: A Systematic Review. 2016;50(1). doi:10.1145/3041960.

Project Team: (Completed once semester begins).

Name	Responsibility

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