CS724: Sensing Communications and Networking for Smart Wireless Devices

PigNet: Failure-Tolerant Pig Activity Monitoring System Using Structural Vibration

Instructor: **Dr. Amitangshu Pal**

Presentation By: Nitish Kumar
Roll: 231110033
Department: CSE (M.Tech)
Session: 2023-2024

About the paper

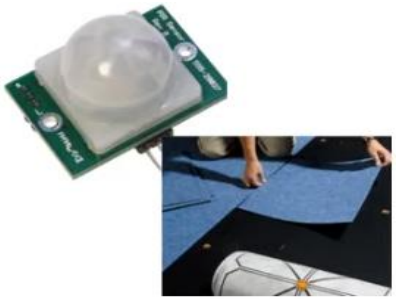
Contributors:

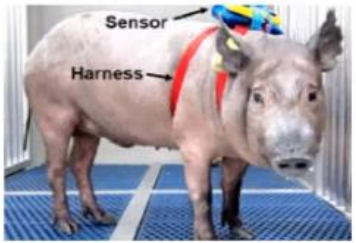
- Amelie Bonde
- Kanittha Naruethep
- Jesse R Codling
- Yiwen Dong
- Shijia Pan
- Sripong Ariyadech
- Akkarit Sangpetch
- Orathai Sangpetch
- Wachirawich Siripaktanakon

◎ Significance of automated livestock behavior monitoring in pig farming.

◎ Existing limitations in video analysis, motion detection, and wearable sensors.

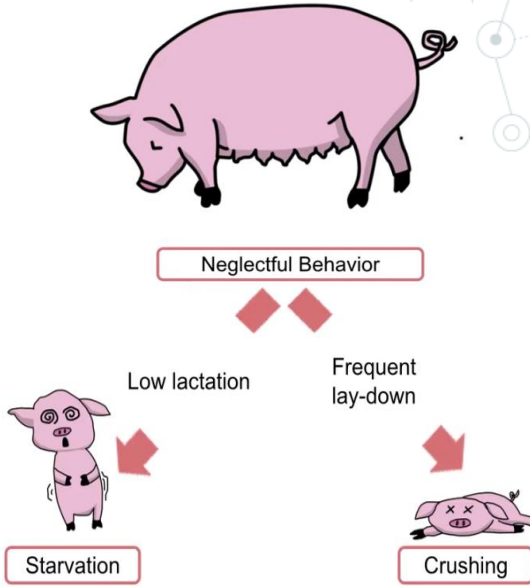
◎ Introduction of "PigNet" as a novel system using structural vibration.



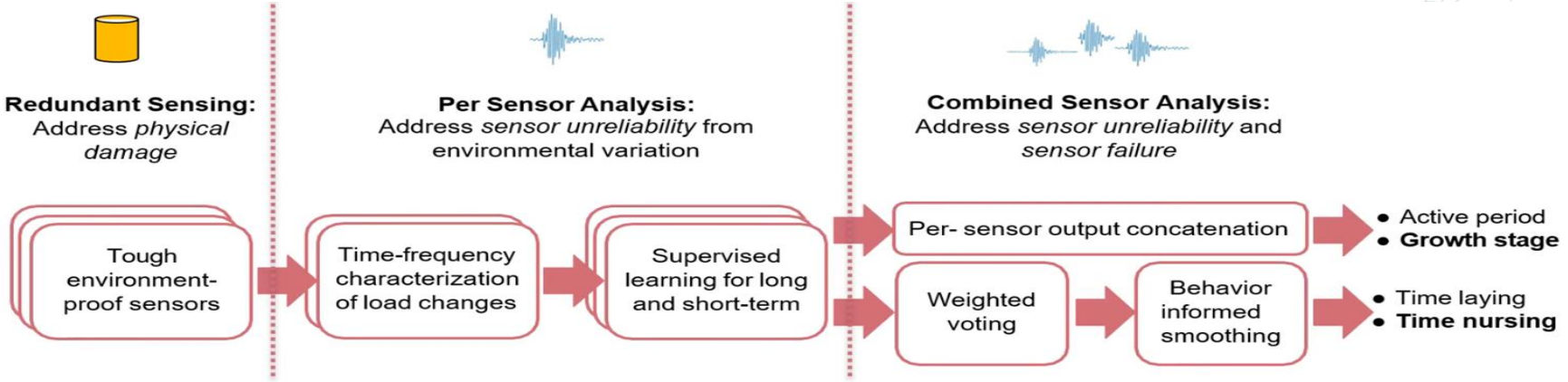


Introduction

- Importance of automated livestock behavior monitoring in pig farming.
- Pig farming global significance and economic factors (mortality, piglet quality).
- Existing limitations in monitoring methods (video, motion detection, wearables).
- Introduction of "PigNet" using structural vibration for monitoring.
- Focus on piglet survival: predicting farrowing and tracking nursing.



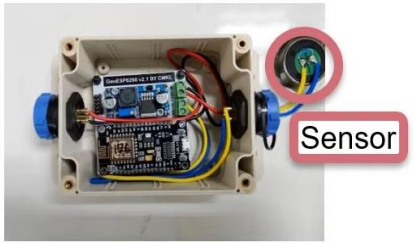
Framework for Activity Recognition with Vibration in a Farm Environment



Environment-Resistant Vibration Sensors

Boxes and sealed cables protect electronics

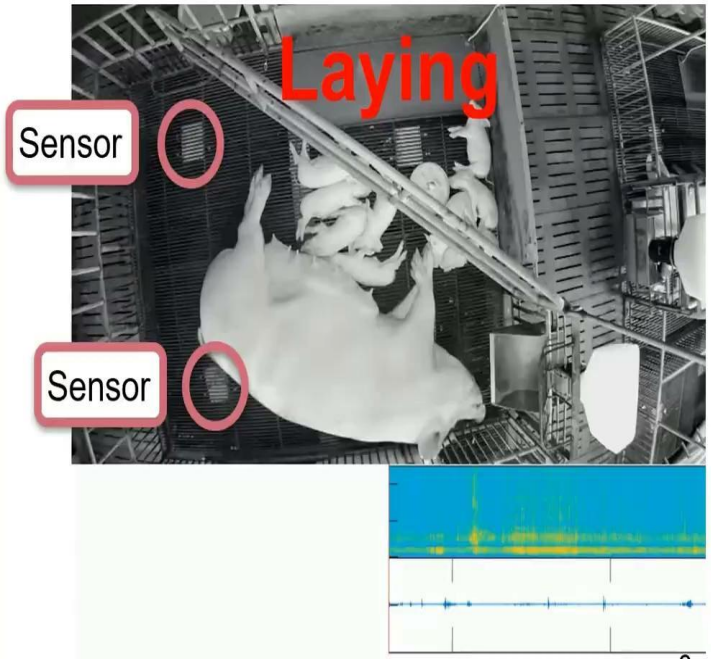
Setup 1: sensor inside protective box



Setup 2: sensor outside box for stronger signal

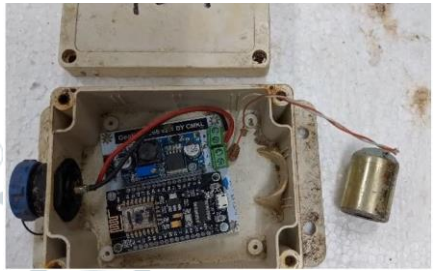
PigNet System Overview

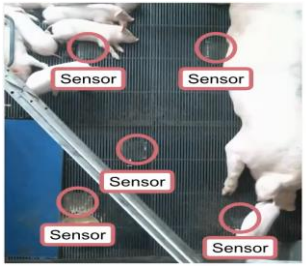
- Introduction to PigNet's core objectives: robust structural vibration-based monitoring.
- Overview of the three main system modules:
  - Redundant Sensing Module (physical fault tolerance)
  - Per Sensor Analysis Module (characterizing pig-induced vibrations)
  - Combined Sensor Analysis Module (maximizing sensor reliability)

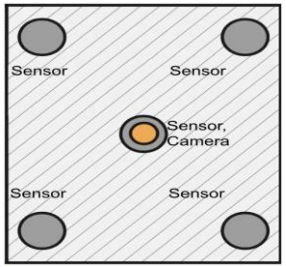


Vibration Sensing Hardware Characterization

- Challenges in hardware design for harsh environments and solutions.
- Explanation of how pig activities influence structural vibrations.
- Use of geophone sensors and their advantages.
- Module for characterizing piglet activities based on vibration data.
- Supervised learning with clustering for monitoring piglet growth.

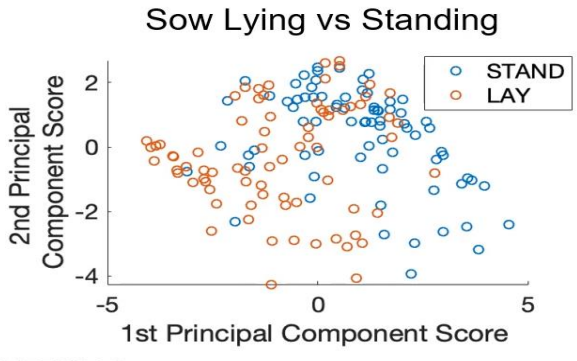


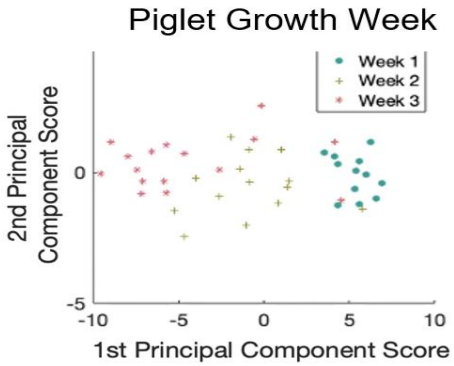




Data Collection and Ground Truth Labeling

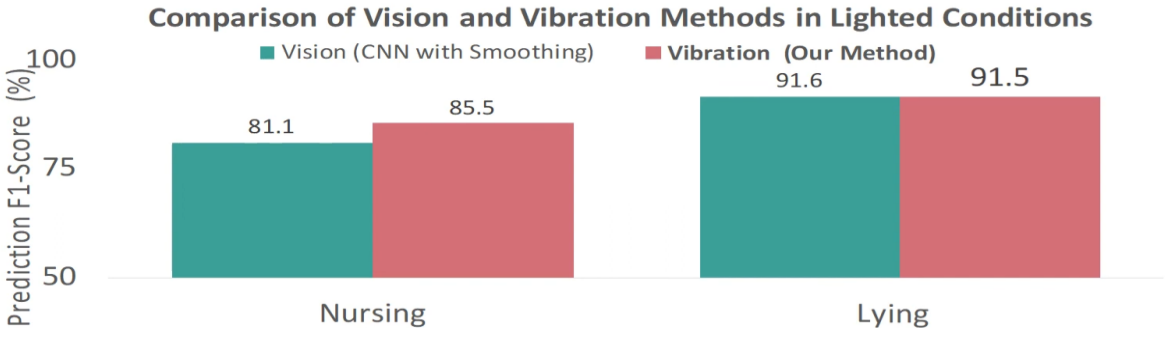
- PigNet was deployed at a Betagro Farm in Thailand for three months.
- Sensors were installed in farrowing pens and crates, monitoring piglet growth and activities.
- Ground truth data was obtained for growth tracking, nursing, lying, and farrowing events.
- Behavioral labeling of nursing and lying activities was done using video footage.



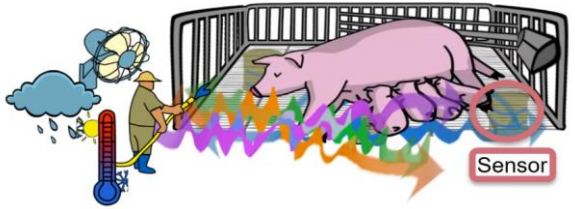


Evaluation Results

- The clustering approach effectively tracked activity changes and growth stages in piglets.
- Nursing and lying detection was achieved with high accuracy, showcasing the robustness of the PigNet system.
- A sequential smoothing algorithm improved the precision of activity detection over time.



Deployment Lessons Learned



1. Environmental Challenges

- Water & Chemical Exposure: Harsh pig pen conditions caused sensor damage.
- Sensor Protection: Achieved with waterproof and corrosion-resistant materials.

2. Hardware Iterations

- Improved Durability: Three hardware iterations to enhance durability.
- Use of IP67 Boxes: Enhanced liquid protection for sensors.

3. Sensor Positioning Insights

- Impact on Accuracy: Sensor location affected monitoring accuracy.
- Optimal Placement: Specific locations for lying and nursing detection.

Related Works

1. Animal Monitoring Systems

- Existing systems for monitoring livestock and animal behavior.
- Challenges: Wearable sensors susceptible to damage and limitations in activity tracking.

2. Structural Vibration-Based Activity Monitoring

- Applications: Identification, localization, activity recognition, and physical condition monitoring
- Limited application in noisy and challenging environments like pig farms.

3. PigNet's Unique Contribution

- Pioneers automated animal monitoring using structural vibrations.
- Tailored for noisy and challenging pig farm conditions.

Conclusion

1. PigNet Innovation

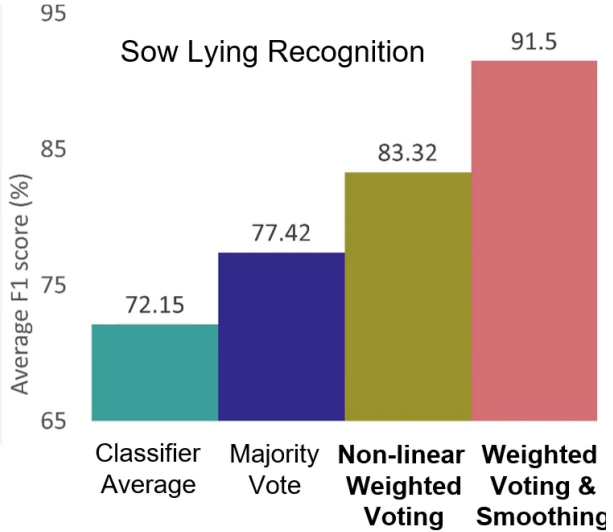
- Novel system utilizing structural vibrations for animal tracking.
- Pioneers automated piglet nursing detection.

2. Robust Design

- Resilient sensors built for harsh pig pen environments.
- Multiple sensors ensure fault tolerance.

3. Impressive Accuracy

- 89% accurate piglet growth week prediction.
- 85% accurate daily nursing activity detection.
- 91% accurate sow lying activity prediction.



4. Practical Farming Applications

- Aids in monitoring piglet feeding, preventing starvation and crushing.
- Reliable sow lying activity predictions for farrowing.

Thanks!

Any questions or suggestions ?

Contact me at:

Mail: nitishk23@iitk.ac.in

nitishk@cse.iitk.ac.in