2019 NSF CYBER-PHYSICAL SYSTEMS PRINCIPAL INVESTIGATORS' MEETING

CPS: SYNERGY: COST-EFFECTIVE MASTITIS CONTROL AND BIOSECURITY FOR SUSTAINABLE DAIRY FARMING

(CNS 1646067)

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Challenge:

- The US dairy producers are estimated to lose over $2 billion annually.
- Mastitis can be caused by many different pathogens through multiple transmission routes, often being asymptomatic, i.e. subclinical mastitis.
- Cost-effective, real-time monitoring of milk quality, pathogens and cow activity is currently unavailable, so mastitis control is extremely difficult.

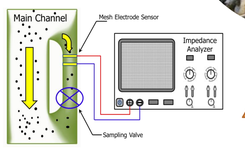
Solution:

- Develop cost-effective, cow-level, real-time monitoring for **SCC**, **pathogens** and **cow activity**.
- Build **a sustainable cyber-physical system for biosecure dairy farms**, which integrates novel sensing, data processing, inference, and control approaches.

Key innovations:

- **Novel biosensors** for low-cost, cow-side and real-time somatic cell counting and multiple causative pathogen identification.
- **Pattern recognition processing** of biosensor signals for much improved accuracy and speed in bio-event detection.
- **Cow tracking and mastitis propagation modeling** for pathogen transmission prediction.

Real time somatic cell counting (SSC) during milking by novel SSC sensor embedded inline.

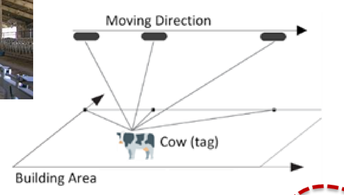


high SSC

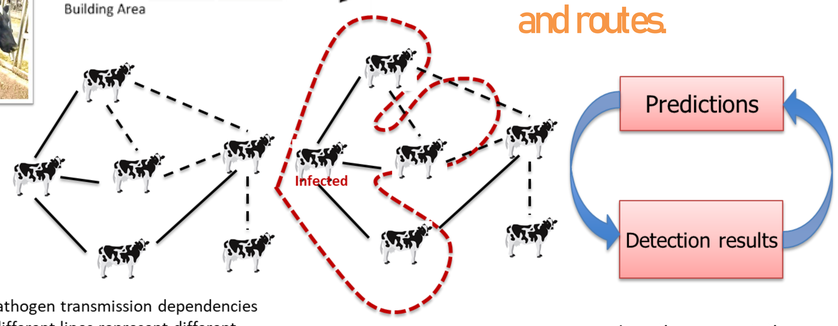
normal SSC
Back to milking.

Onsite pathogen detection by ACEK capacitive sensor. Treatment.

Form action plan.
- Cleaning.
- Testing selected cows.
- Treatment.



Tracking cow movement to identify transmission sources and routes.



Pathogen transmission dependencies (different lines represent different probabilities)

Identifying highly risky groups

Iterative computation

Scientific Impact:

- Innovative microfluidic biosensing methods integrated with topological classification will enable in-line somatic cell counting and point-of-care high-sensitivity detection of pathogen panel.
- The proposed approaches can be extended to other biosensing applications, leading to significant advancement in developing low-cost, real-time, high-accuracy bio/chemical sensors.
- GPS localization and tracking of cattle movement and disease propagation dynamics modeling t can be used for pathogen tracking in general and for confined animals in particular.

Broader Impact:

- Mastitis control is of significant economic value, especially to dairy farms, milk production and milk product processing.
- The project provides the US dairy farmers with an integrated low-cost solution for effective control of cattle mastitis, directly contributing to and impacting the sustainability of the dairy industry worldwide.
- The developed technologies are applicable to health care, not only reducing cost and time for triage, but also advancing the current model of patient care by allowing real time monitoring of biomarker levels of people.
- The research will provide interdisciplinary training to both graduate and undergraduate students. New cross-disciplinary class modules will be developed based on the research findings.