Closed-Loop Sustainable Precision Animal Agriculture

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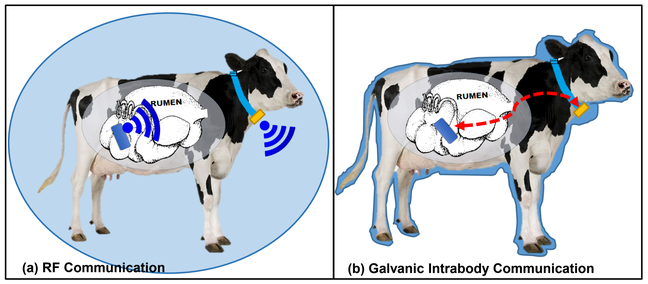
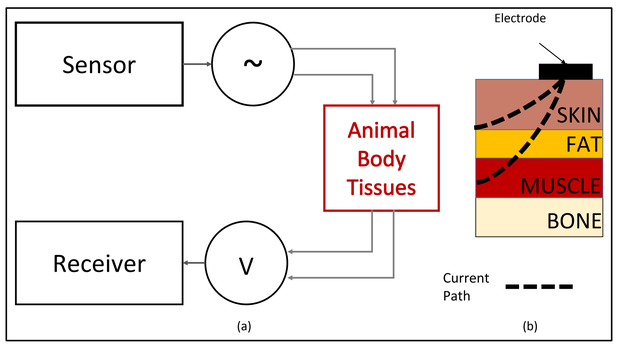
Body Area Sensor Network

Precision Animal Ag necessitates customized care for each animal which can only be achieved by real-time continuous monitoring. Implanted sensors used for this purpose need a reliable, safe, and low power network to communicate. Hence, we propose the use of body area sensor network with galvanic coupling.



Comparison of the field radius of RF and Intrabody Communication.

- Galvanic Coupling, based on electro-quasistatic communication, utilizes the inherent conductivity of body tissues to transmit signals.
- Signal leakage is <15cm around the body and low signal absorption, hence 100x less power consumption and increased security.



Galvanic Coupling*: (a) Basic Circuit layout and (b) Dissipation of current through the layers of body tissues.*

Project Support

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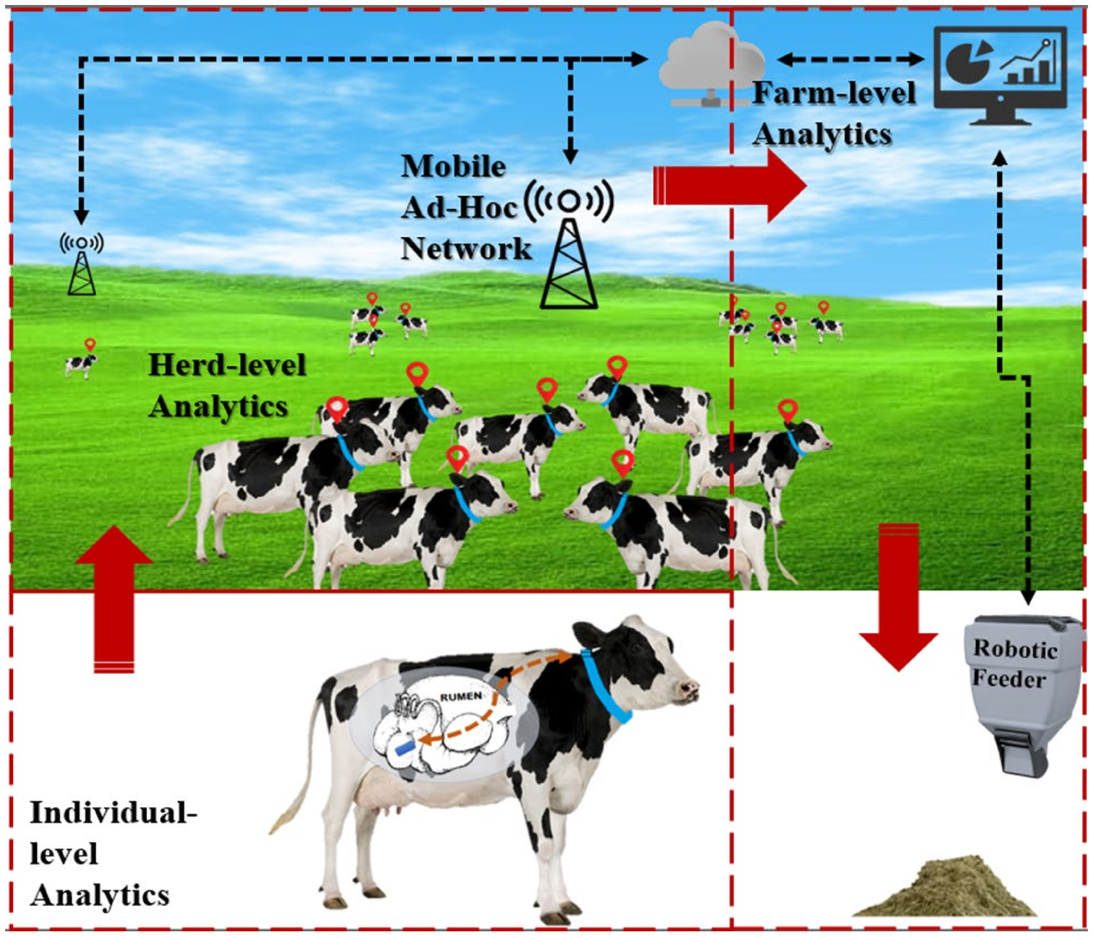
Precision Animal Agriculture – CPS Reference Architecture

- With dairy forms now comprising 30,000-head of cattle, or more, **Precision Animal Ag** is returning the personalized, individual touch of the "family farm" to the diary industry through data analytics.
- A multi-tiered, data-centric network is proposed to monitor and actively control efficiency, safety, and quality of U.S. dairy farms at the farm, herd, and individual levels.



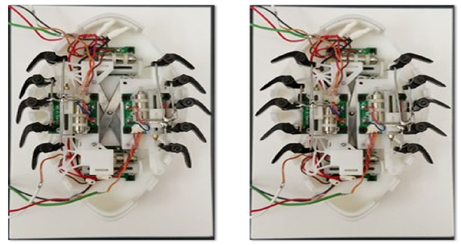
Layout of the Precision Animal Agriculture CPS Reference Architecture.

Scientific Impacts

- Unprecedented use of galvanic intrabody communication for animals
- A generic Precision Animal Ag CPS reference architecture which is customizable and reconfigurable.
- Creating new science by correlating psychological and metabolic markers for individual animal health models.
- Addressing global sustainability by monitoring and controlling methane expulsion and pollution of soil and water.
- Creating novel methods of measuring metabolic markers such as VFAs and pH.
- Revolutionary robotic solutions for high precision data collection and control.

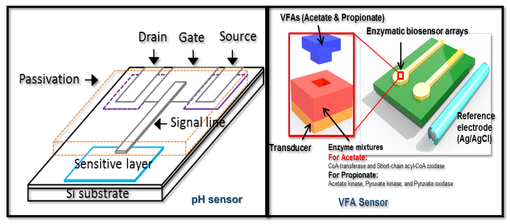
NRI – RUMENS Robot and Sensors

Data-centric approach of this precision CPS architecture starts with sensors and in a companion NRI project, we are developing in-vivo sensing and sampling packages for the RUMENS robot that will gather critically important data in real-time.



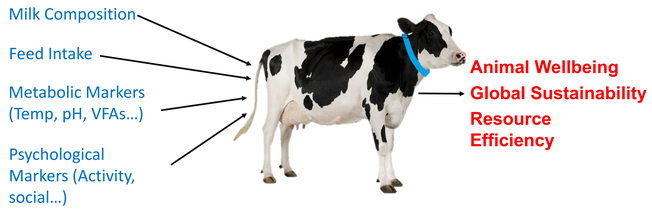
In-vivo robot prototype

- Active Sensing millipede inspired RUMENS robot uses travelling wave for locomotion.
- Novel Volatile Fatty Acid (VFA) sensor measures the concentration of VFAs which help to gauge the metabolic health of the animal.
- Sensor package: Temperature, pH, and VFA.



Data Modeling and Analytics

- Animal nutritionists White and Daniels are gathering data from animal feed experiments on feed intake versus numerous metabolic parameters.
- Advanced data-driven algorithms are being created to adapt the nutrition models to individual animals.



- Reconfigurable analytics engines that embody the estimation and control algorithms in a reusable form are also being created.

Collaborative Robotics Lab