Greener Pastures: A Pasture Sanitation Cyber-Physical System for Environmental Enhancement and Animal Monitoring

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While crop-based agriculture has adopted precision and autonomous technologies to improve crop production and reduce environmental impacts, similar technologies have not been readily adopted by grazing livestock systems. At the core of modern nutrient management in livestock pastures is the concept of critical source area management: i.e., minimizing the availability of nutrients in areas that are hydrologically active and connected with stream networks, which is traditionally done by limiting the time and or the number of animals in any given pasture. However, reducing the water quality impact of pastured livestock, without reducing livestock, could be substantially improved by integration of cyber and physical systems (CPS). CPS provide a rich environment for research and applications that will have joint benefits in the fields of robotics, computational sciences, environmental science, and animal sciences. The overall objective of this project is to create an integrated sensing and actuation system to manage manure deposited in grazing livestock ecosystems.

Key problems and their significance

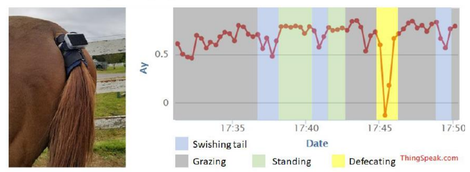
- Manure in pastures contaminates downstream water supply
  - Mitigation techniques decrease pasture usage
    - Significance; Decrease pasture productivity
  - Direct mitigation requires manual labor
    - Significance: Manual labor is expensive and difficult to find
  - No autonomous robotic mitigation tools exist
    - Significance: Autonomous crop-directed systems have benefited agriculture, but pasture-directed systems do exist
  - Pasture animal may not tolerate autonomous platform in the pasture
    - Significance: Solutions must be accepted by pasture inhabitants

The solution, approach, new contributions

Develop autonomous platform to redistribute nutrients/manure within the pasture. This solution requires the following approach:

- Studying grazing animal behavior in the presence of an autonomous robot within the pasture using Pasture Sanitation Robot 1 (PSR1).
- Determining specifications for an autonomous robot to perform manure management within grazing livestock pasture and create PSR2.
- Verifying system performance in empty pastures and assessing system performance in populated pastures.

This work will contribute better pasture utilization and better prevention of water contamination.



Scientific impact. How does this contribute to other CPS's?

- CPS/Animal interaction data collection and development of habituation strategies
- Autonomous monitoring of changes in complex terrain and nutrient dispersion
- Sharing of open-source data and CPS-directed robot packages

Broader implications (society)

- Cleaner drinking water
- Reduction in downstream contamination
- Reduction in nutrient imbalance in pasture
- Reduced maintenance labor expenses
- Increased pasture productivity

Broader implications (education and outreach)

- Hosting of underrepresented minorities
- Community outreach to K-12 with educational sessions and hosting tours
- Engagement of stakeholders
- Undergraduate research experiences

Broader implications (quantify potential impact)

- ~150 kg N per animal per year
- Lower labor costs for pasture maintenance

2021 NSF Cyber-Physical Systems Principal Investigators' Meeting
June 2-4, 2021

Proposal #: 2020-11362