An IoT Architecture for Decision Support System in Precision Livestock

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Abstract. *Sustainable animal production is a primary goal of technological development in the livestock industry. Thus, livestock production systems require monitoring, reasoning, and mitigating unwanted conditions with automated actions. The principal contribution of this study is the introduction of a self-adaptive architecture named e-Livestock to handle animal production decisions. Two case studies were conducted involving a system derived from the e-Livestock architecture, encompassing a Compost Barn production system - an environment and technology where bovine milk production occurs. The outcomes demonstrate the effectiveness of e-Livestock in three key aspects: (i) abstraction of disruptive technologies based on the Internet of Things (IoT) and Artificial Intelligence, (ii) support for the reuse and derivation of an adaptive self-architecture to support the engineering of a decision support system for the livestock subdomain, and (iii) support for empirical studies in a real smart farm to facilitate future technology transfer to the industry.*

Resumo. *Na indústria pecuária, a produção animal sustentável é o principal objetivo do desenvolvimento tecnológico. Assim, os sistemas de produção pecuária requerem monitoramento, controle e mitigação das condições indesejadas através de ações automatizadas. A principal contribuição deste estudo é a introdução de uma arquitetura auto-adaptativa denominada e-Livestock para apoiar as decisões relacionadas à produção animal. Foram conduzidos dois estudos de caso, envolvendo a arquitetura e-Livestock, que foi utilizada no sistema de produção Compost Barn - ambiente e tecnologia onde ocorre a produção de gado leiteiro. Os resultados demonstraram a utilidade do e-Livestock para avaliar três aspectos principais: (i) abstração de tecnologias disruptivas baseadas em Internet das Coisas (IoT) e Inteligência Artificial, (ii) suporte para a reutilização e derivação de uma arquitetura auto-adaptativa para apoiar o desenvolvimento de uma aplicação de apoio à decisão para o subdomínio da pecuária e (iii) suporte para estudos empíricos em uma fazenda inteligente real para facilitar a transferência de tecnologia para a indústria.*

1. INTRODUCTION

The Internet of Things (IoT) is essential in agriculture and livestock, using wearable devices and biosensors to track activities and monitor animal health. This data aids decision-making for producers and managers. Hence, aiming to tackle the challenge of providing an architecture that meets the needs of a smart farm, encompassing processing, integration, and intelligence, we developed an architecture for DSS, called e-Livestock. Therefore, the research problem addressed in this work is **to analyze** the support to monitor the environment, reason on data, and automate actions **from the** researcher's/farmers' point of view, **in the context of** a smart farm system. The research question is ***"How can e-Livestock support automated monitoring, reasoning and actions in smart farms?"***. The e-Livestock architecture was designed to gather new knowledge at runtime to resolve uncertainties, reason about itself, its context, and goals, and adapt based on actuators to achieve goals. We conducted case studies in a Compost Barn PS for dairy cattle to assess the proposed solution. The complete case studies can be found in Gomes, J. et al (2023). [Gomes et al. 2023].

1.1. ARCHITECTURE DECISION E-LIVESTOCK

Our case study scenario consists of data monitoring, collecting, and processing and then analyzing the data from a production system called Compost Barn, located at Embrapa – Coronel Pacheco, Brazil. We used data from sensors collected by researchers from Embrapa between 2020 and 2021 [Gomes et al. 2023]. Thus, we could have evidence to answer the raised RQ, the e-Livestock supports automated monitoring, reasoning, and actions in smart farms using ontology inferences combined with machine learning abilities.

1.2. FINAL REMARKS

As a contribution of this work, we have published the systematic mapping [Gomes et al. 2021b], the first version of the architecture [Gomes et al. 2021c], the ontology model [Gomes et al. 2021a], the second cycle [Gomes et al. 2023], and [Gomes et al. 2022]. In addition to its contributions to decision support, the proposed solution may benefit research groups working on decision-making platforms.

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