Problem Statement and Goals
SFWRENG 4G06

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Table 1: Revision History

Date	Developer(s)	Change
Sep/23/2024	Aryan Patel	Developed Problem Statement and Stretch Goals sections
Sep/23/2024	Krish Patel	Refined sections Problem Statment, Stretch Goals as well as developed Challenge Level and Extras and Reflection sections

1 Problem Statement

1.1 Problem

Dairy farmers face significant challenges in managing the health, productivity, and breeding outcomes of their herds. Traditionally, these issues are managed reactively, with farmers responding to problems such as health declines, breeding failures, or unexpected herd turnover after they occur. This reactive approach leads to inefficiencies, financial losses, and reduced herd performance. Our project, in collaboration with CATTLEytics Inc., aims to address these challenges by implementing a machine learning (ML) model capable of predicting breeding success rates and the likelihood of animals leaving the herd based on historical data. This model will help farmers transition from reactive to proactive herd management, improving overall farm productivity and decision-making. The model will integrate with CATTLEytics Inc.'s existing systems, allowing seamless adoption by farmers.

1.2 Inputs and Outputs

Inputs

The software will use historical herd data related to health, productivity, and breeding outcomes. This data may include metrics such as individual animal health records, breeding attempts, and farm-specific environmental conditions. The input data will be fed into a machine learning model to generate predictions.

Outputs

The output will consist of predictive insights aimed at improving farm management. These will include:

1. Predictions about the success of breeding attempts for individual animals.
2. The likelihood of an animal leaving the herd.
3. Alerts about potential health issues or productivity declines.

The software will provide clear, actionable outputs to guide decision-making, presented in a format easily interpretable by farmers and other stakeholders.

1.3 Stakeholders

1. **Farmers:** The primary users of the software, who will benefit from improved herd management and decision-making.
2. **CATTLEytics Inc.:** The company that will deploy the software to its customers and provide ongoing support.
3. **Animal Health Experts:** Professionals who may use the software to provide advice to farmers based on the predictive insights generated.
4. **Regulatory Bodies:** Organizations that may use the software to monitor herd health and productivity.
5. **Dairy Production Companies:** Organizations that may use the software to optimize their supply chain and production processes.

1.4 Environment

Hardware

The software will be deployed in farm management systems typically used on standard personal computers or servers. These systems may also interact with IoT devices used for real-time data collection on farms.

Software

The model will be integrated into CATTLEytics Inc.'s farm management platform, leveraging their existing infrastructure. It will seamlessly integrate into the farmers' existing workflow, ensuring compatibility with the tools and systems they are already using.

2 Product Goals

Goal	Importance
The model accurately predicts breeding success rates for individual cows.	The accuracy of predictions can be measured by comparing the predicted success rates with actual outcomes over a defined period (e.g., a breeding cycle). A target accuracy rate, such as 80-90%, can be established to define success.
The model provides predictions on the likelihood of an animal leaving the herd.	This can be measured by tracking the model's predictions against actual herd turnover rates. A success threshold (e.g., 75% accuracy or better) for predicting cows that will leave the herd within a specified time frame can be set.
The system integrates seamlessly into CATTLEytics Inc.'s existing platform.	Success can be measured by the time taken to complete the integration and the absence of major system disruptions post-integration (e.g., within a 1-month test period, there should be less than 1% downtime or user-reported issues).
The system offers user-friendly, actionable insights for farmers.	User-friendliness can be measured through user feedback surveys post-implementation, focusing on ease of use and clarity of insights. A target of 80% or more of users rating the insights as "clear" or "actionable" can be set as a measurable goal.

3 Stretch Goals

Goal	Importance
The model processes real-time data to provide up-to-date predictions.	Real-time predictions allow farmers to respond quickly to changes in herd dynamics, preventing potential issues.
The system includes a feature for predicting long-term health trends of individual cows.	This would enable farmers to anticipate health problems and intervene early, leading to better animal welfare and reduced veterinary costs.
The model can be customized for different farm sizes and breeds.	Customization increases the model's marketability, allowing it to be adapted to various farm environments and specific herd characteristics.
The system offers encrypted data storage and transmission to ensure data security.	Data security is crucial for farmers and companies that handle sensitive herd information. This feature increases trust and protects data integrity.

4 Challenge Level and Extras

The challenge level for this project is general. The project requires applying machine learning techniques to real-world problems in dairy agriculture. This requires a solid understanding of software engineering principles and machine learning concepts. It also demonstrates the ability to integrate multiple domains, such as software development, data analysis, and some domain-specific knowledge in agriculture. An additional challenge lies in developing user-friendly interface and/or application that allows farmers and researches to interact with the ML model.

Additionally, we seek to add benchmarking, specifically for various ML algorithms, extensive documentation, and incorporate usability testing for our Extras.

Appendix — Reflection

What went well while writing this deliverable?
Our team collaborated effectively during the process. Prior to meetings, we engaged in discussions, that allowed for the fair allocation of work. This resulted in a smooth workflow, where each member was prepared to contribute. Additionally, the quality of the work produced aligned well with the rubric, which boosted our confidence that the deliverable would meet course expectations.

One of the major successes was establishing goals after discussions with CATTLEytics Inc. stakeholders. These discussions not only clarified the problem we are solving but also led to valuable insights into metrics needed to track our model's success. This deliverable opened up several points for further exploration, including additional work we may need to consider and how we would evaluate the performance of our system.

What pain points did you experience during this deliverable, and how did you resolve them?
One significant challenge we encountered was understanding the domain knowledge specific to dairy farming and herd management. Since none of us had direct experience in this area, it was initially difficult to determine how we could effectively measure the success of the machine learning system we are building. We addressed this issue by having in-depth discussions with the stakeholders at CATTLEytics Inc., who helped clarify the domain requirements and provided key insights on success metrics.

Another pain point was developing stretch goals. On paper, the system followed a fairly straightforward process, which made it challenging to come up with additional features that would provide significant value. We resolved this by brainstorming ways to extend the system's capabilities, such as real-time data processing and customization for different farm sizes or breeds, to align with the broader goals of improving herd management.

How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?
Initially, we felt the project might be too straightforward for a Capstone-level endeavor. To address this, we refined our scope by incorporating stretch goals that would leverage our prior experience while ensuring we didn't overextend ourselves. These stretch goals allowed us to expand the project's technical depth without deviating from its core objectives. We also carefully considered the complexities of working with both ML technologies and the dairy agriculture sector, factoring in the unique challenges posed by each when defining both our immediate goals and stretch targets. This approach helped ensure the project maintained a suitable level of complexity while remaining feasible.