Real-Time Detection of Parturition Onset in Small Ruminants Using Wearable Accelerometers and Machine Learning

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Context and motivation

Traditional monitoring

- Birth losses rates can reach 10%
- Manual monitoring is labor-intensive and often impractical

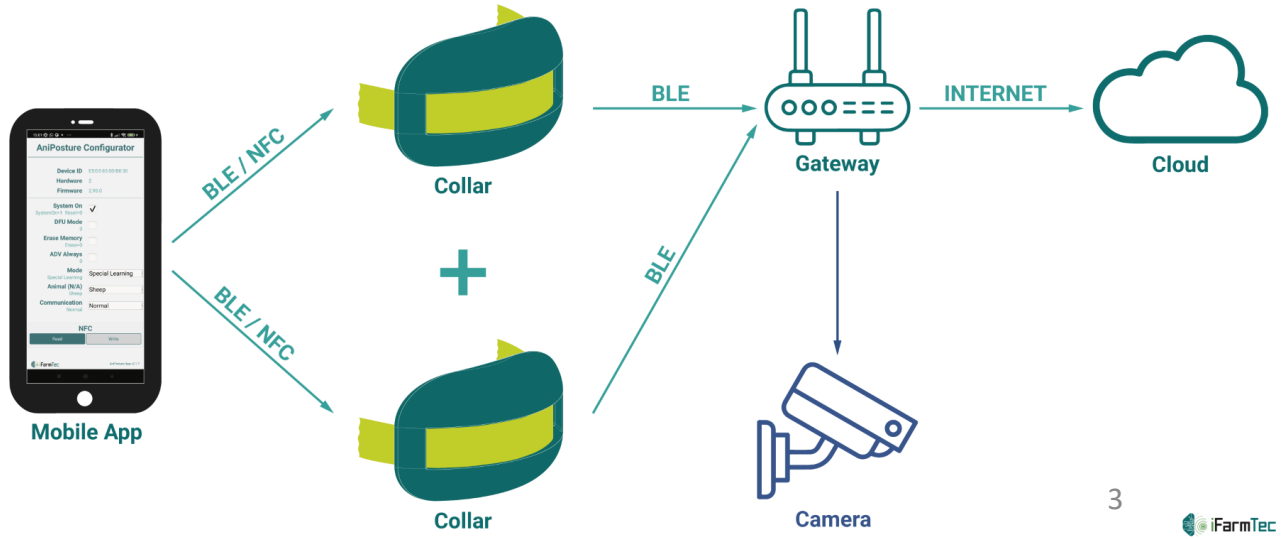
Smart Technology

- Continuous, non-invasive monitoring
- Enable timely intervention
- Wearable accelerometers are a convenient solution

System architecture

Key components:

- **Wearable Collars:**
  Equipped with inertial sensors and thermometers
- **Cameras:**
  Provide visual data for monitoring and verification
- **Gateway:**
  Gathers data, implements data classification and triggers alarms

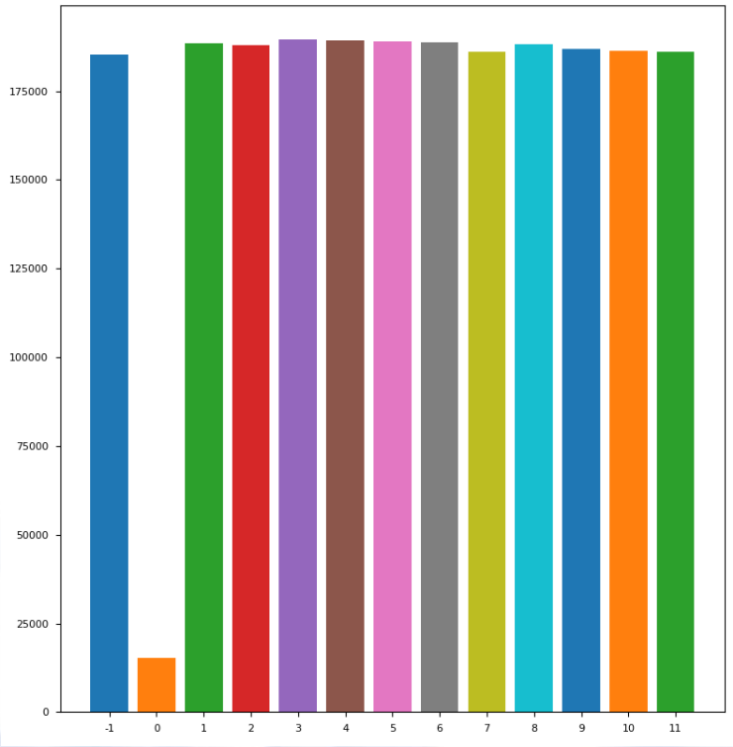


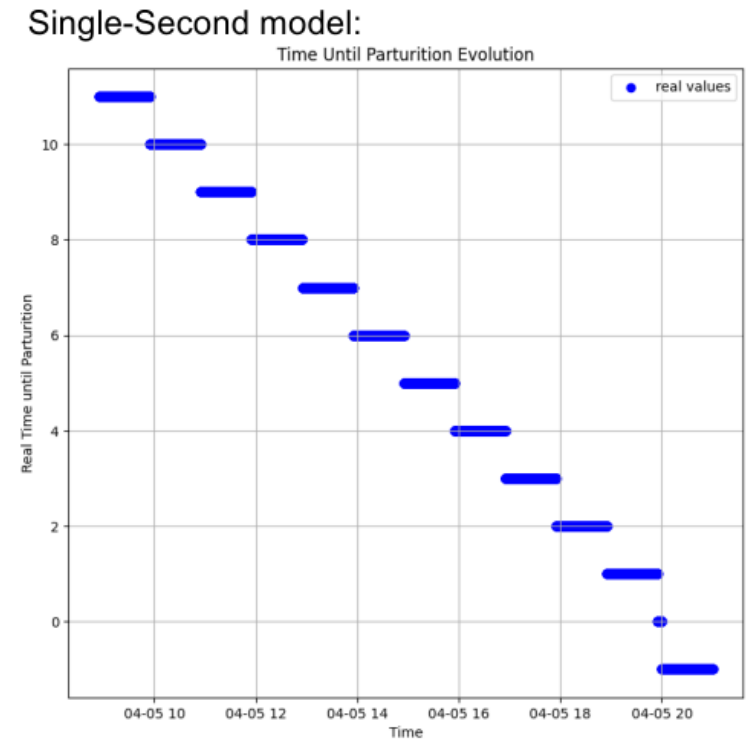
Dataset Overview

- 62 ewes
- 27 unassisted births, 35 assisted births, 4 inverted collars.
- Ewes lambed between one to three lambs
- All births documented through sensor data and video recordings (12 hours each).
- Frequency of 20 Hz

Dataset Processing

- Identification of time of birth and labeling of the data.



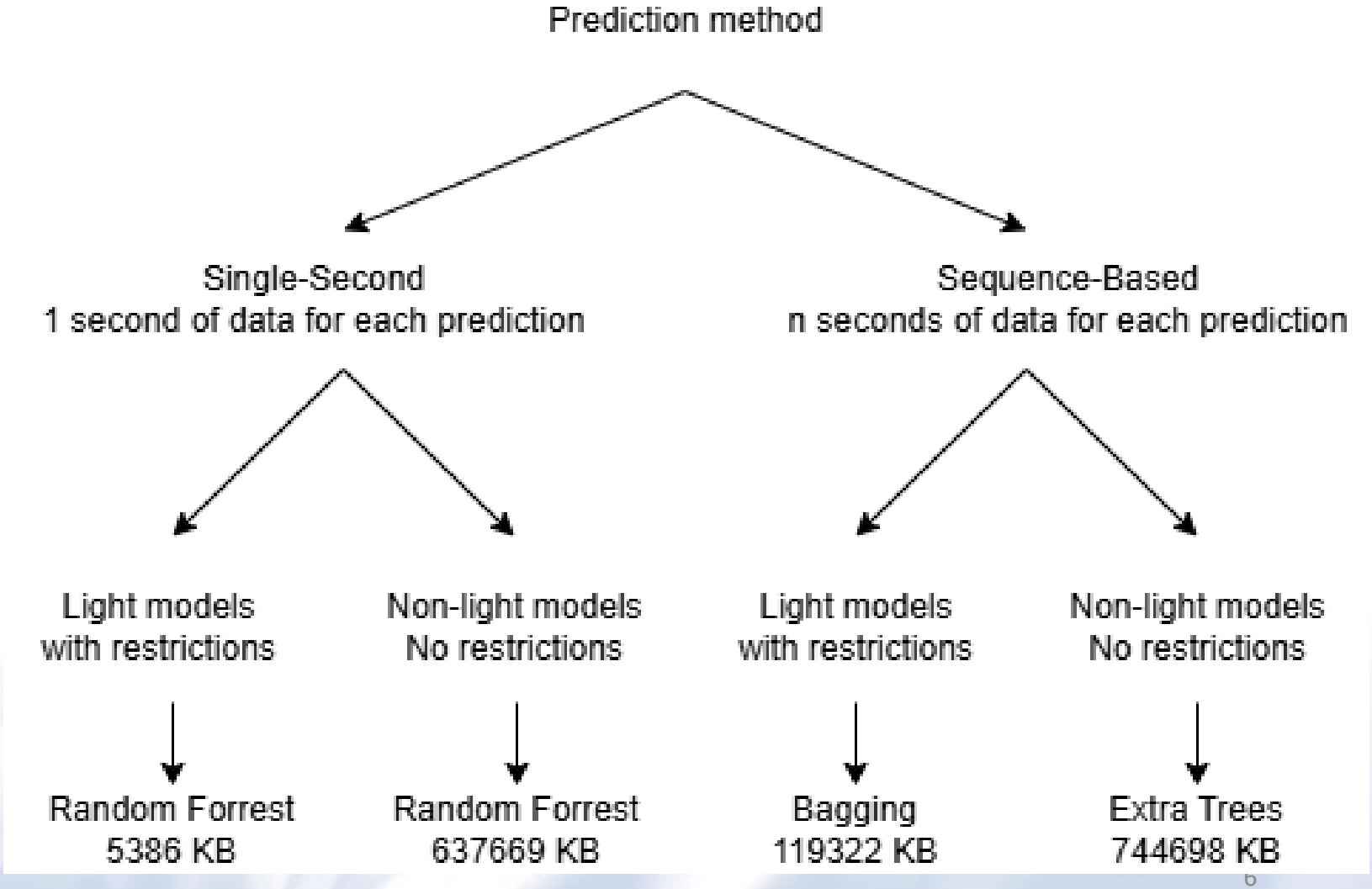


Model Development

Temporal Processing:
- Single-Second
- Sequence (Window-Based)

Computational Complexity:
- Light
- Non-Light

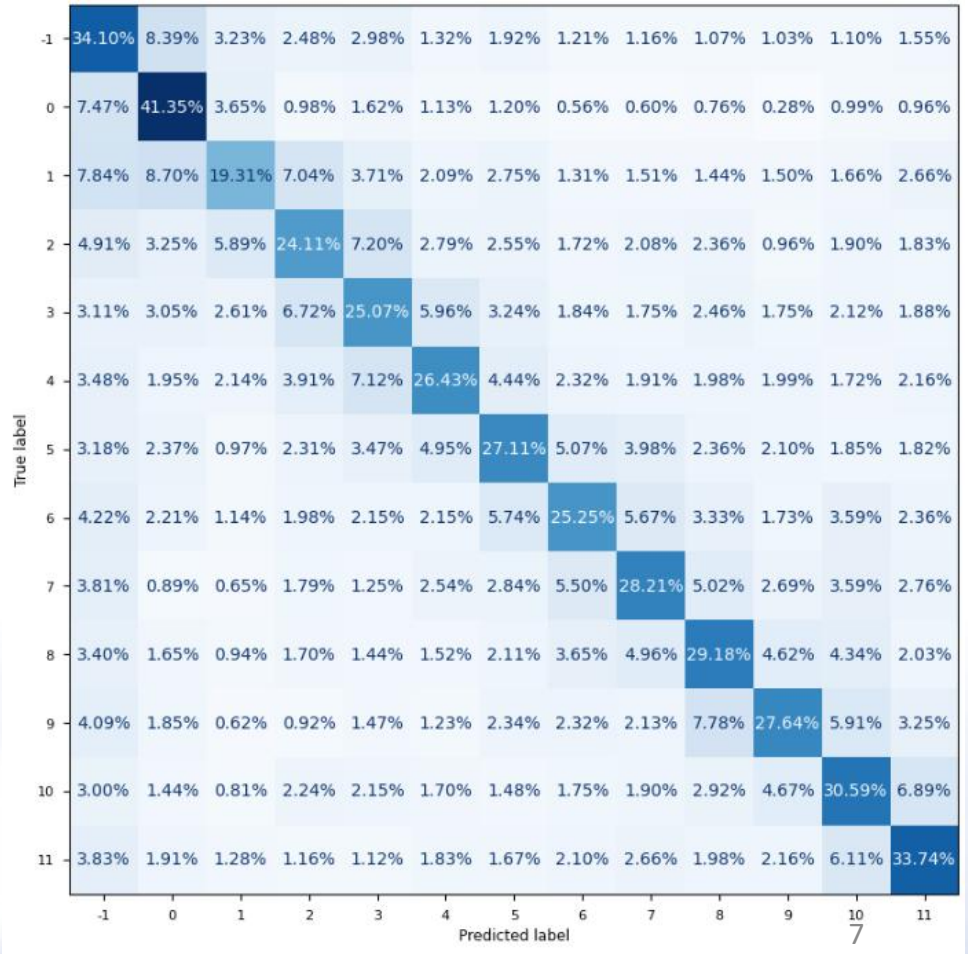
Models Tested:
- Decision Tree
- Random Forrest
- Extra Forrest
- Bagging



Results: Single-Second Model (Light)

Model	Accuracy	Precision	Recall	F1-score	MCC
DecisionTreeClassifier	0.30	0.31	0.30	0.30	0.24
RandomForestClassifier	0.47	0.47	0.47	0.46	0.42
ExtraTreesClassifier	0.46	0.46	0.46	0.46	0.42
Bagging	0.17	0.17	0.17	0.17	0.10

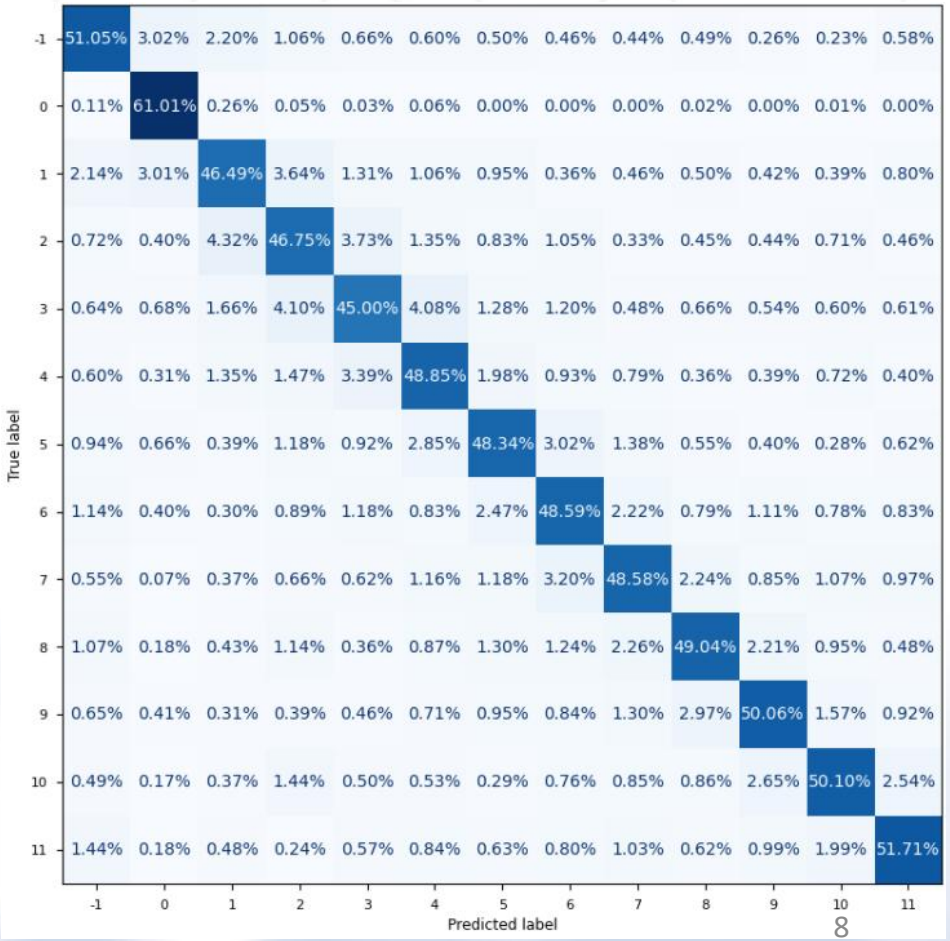
Best Performing model: Random Forrest Classifier
Size (KB): 5386



Results: Sequence-Based Model (Non-Light)

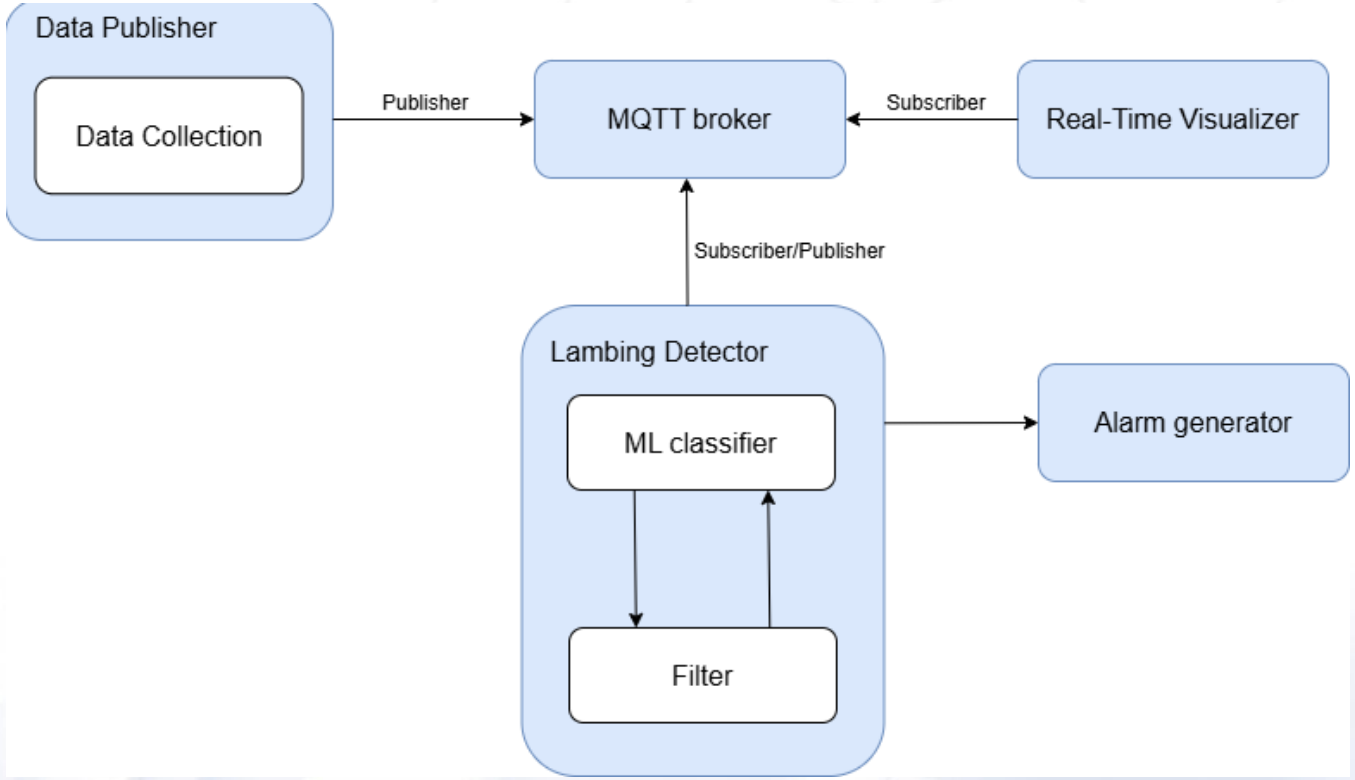
Model	Accuracy	Precision	Recall	F1 Score	MCC
DecisionTreeClassifier	0.51	0.51	0.51	0.51	0.47
RandomForestClassifier	0.77	0.77	0.77	0.77	0.75
ExtraTreesClassifier	0.81	0.81	0.81	0.81	0.79
Bagging	0.65	0.65	0.65	0.65	0.62

Best Performing model: Extra Trees Classifier
Size (KB): 744698



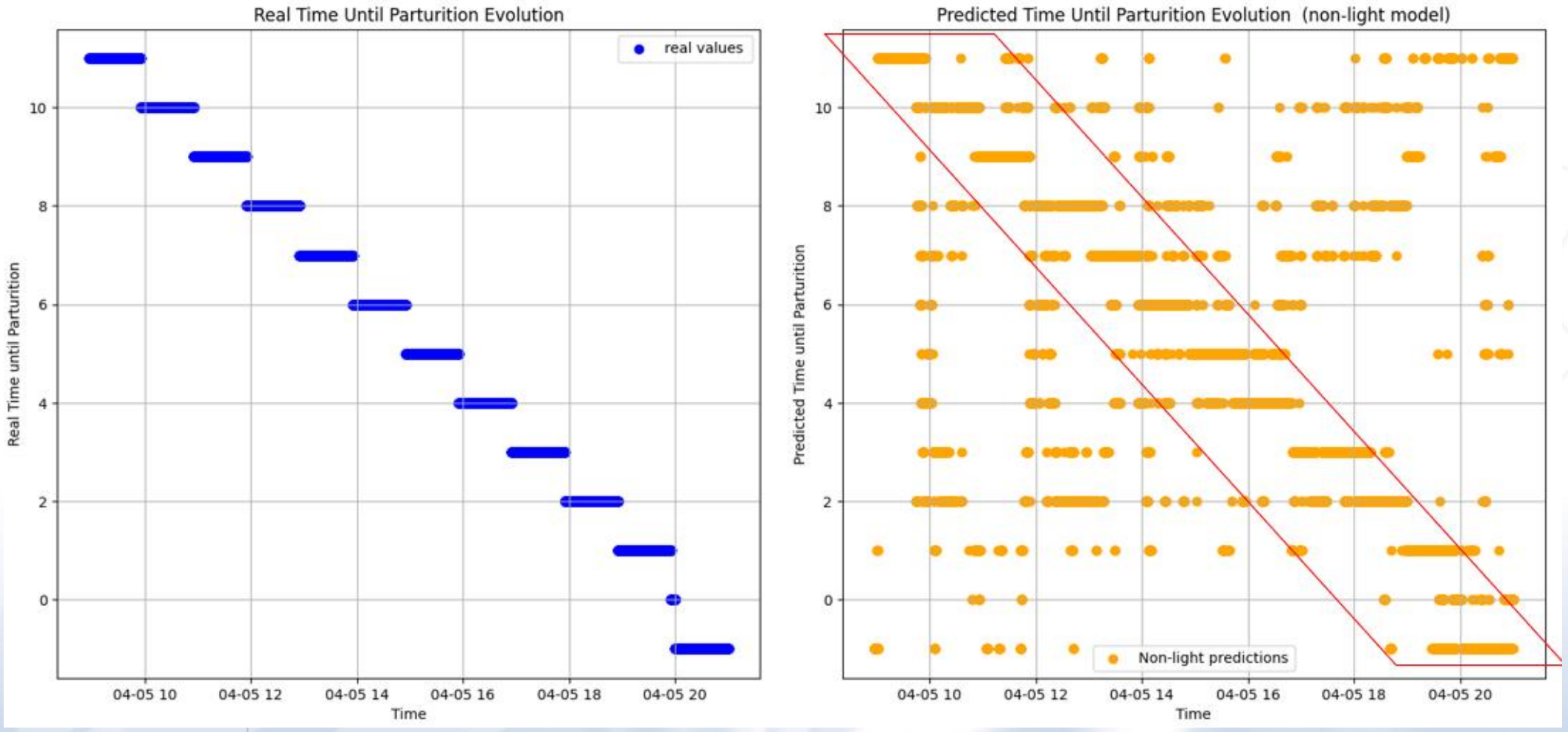
Detector architecture

- **MQTT Broker:** Handles communication between components
- **Data Publisher:** Functions as the data acquisition interface
- **Model Classifier:** Processes sensor data using trained predictive models
- **Filter:** Applies post-processing to enhance prediction stability
- Alarm Generator and Real-Time Visualizer



Prediction Mapping Over Time

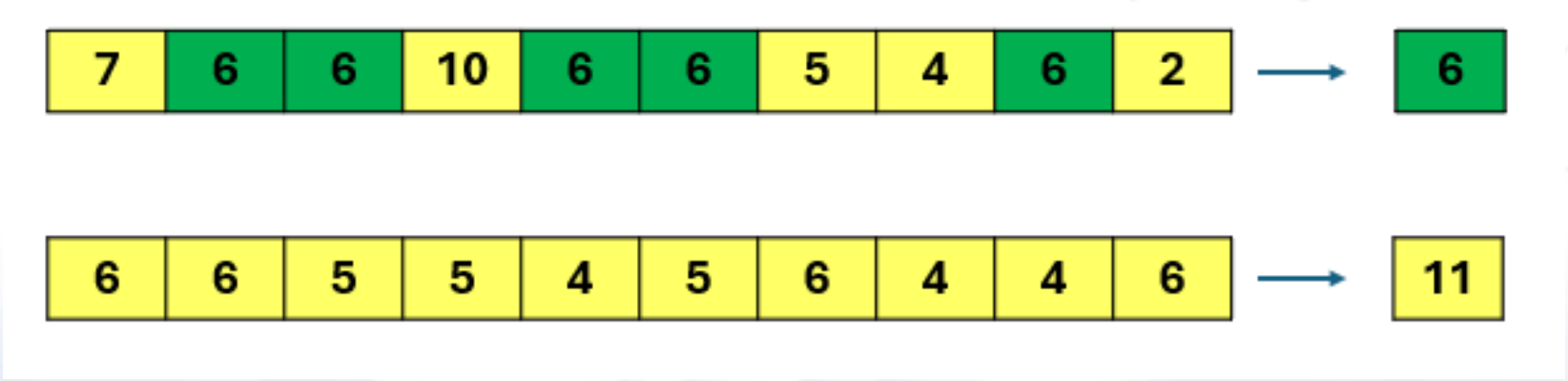
Sequence-based model:



Temporal Filtering: Enhancing Predictive Stability

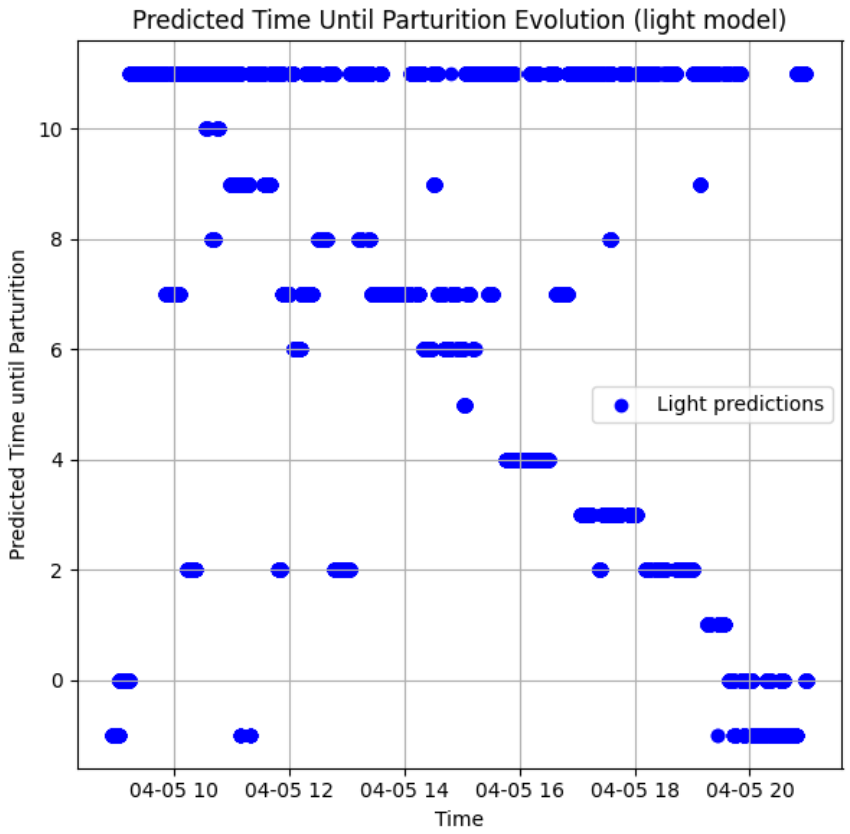
Decision Criteria:

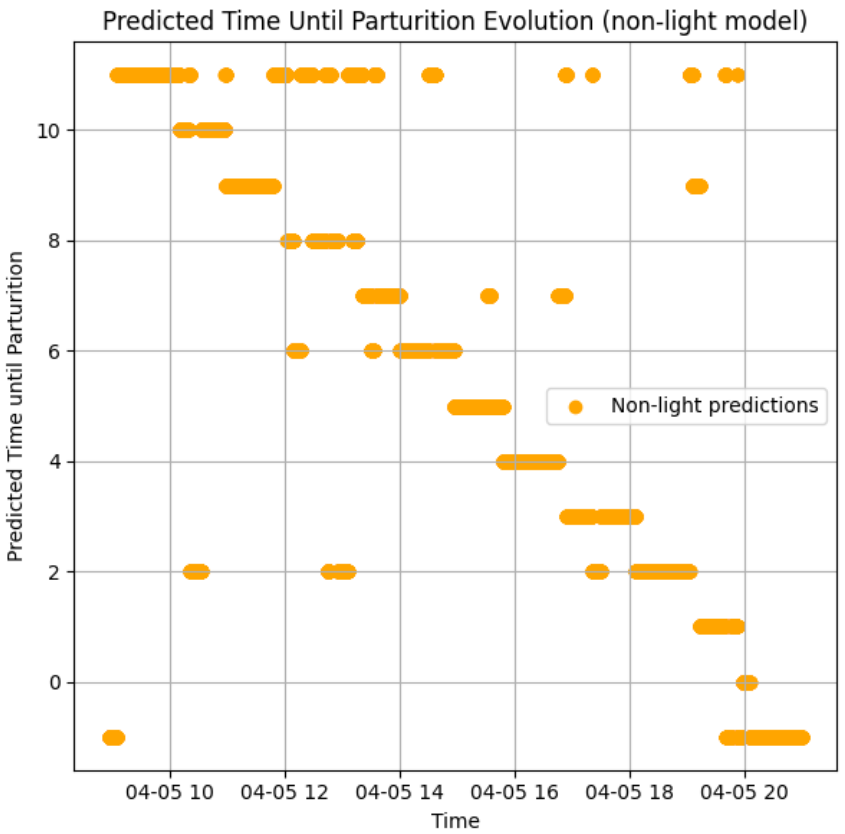
1. Most frequent prediction within window selected
2. Prediction must appear in ≥40% of window observations
3. If no prediction meets 40% threshold - Defaults to Class 11 (furthest from parturition)



Results: Temporal Filtering

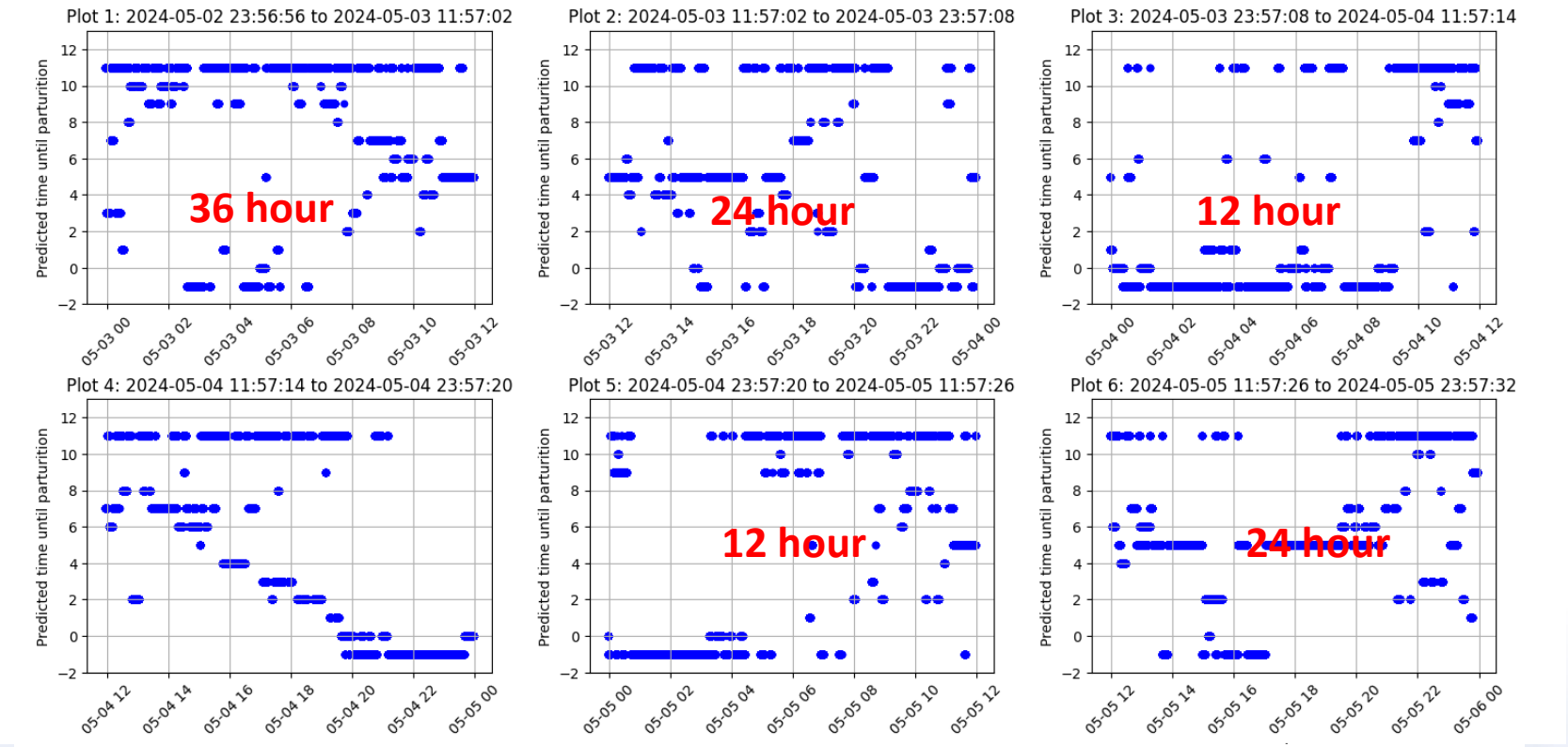
Model	Accuracy	Precision	Recall	F1-score	MCC
RandomForest (light)	0.34	0.68	0.34	0.36	0.31
ExtraTrees (non-light)	0.71	0.78	0.71	0.72	0.70





Extended Validation

- Scattered pattern persists in periods far from parturition
- Organized descent pattern appears exclusively near birth



Enhanced Filtering: State Memory

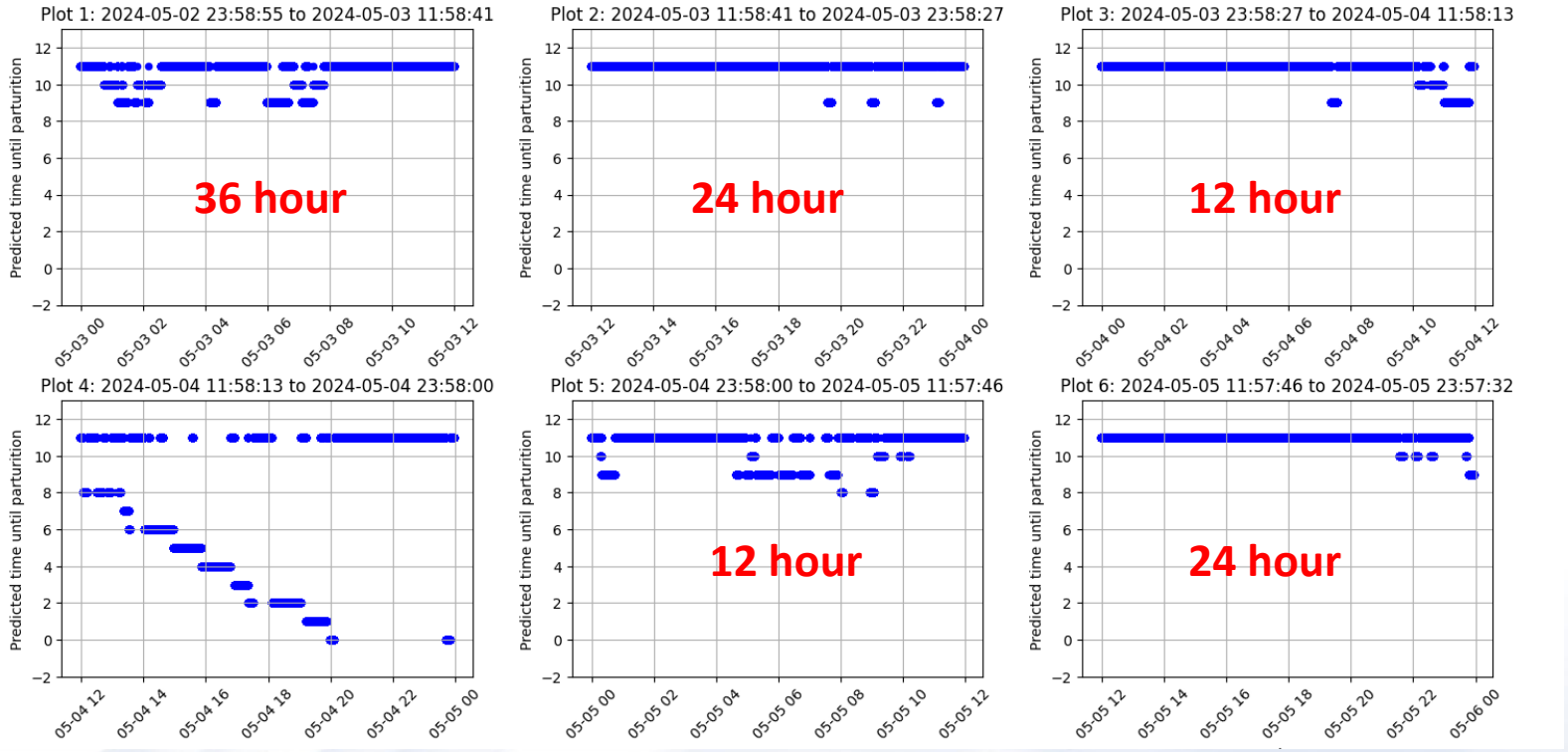
Transition Constraints:

In Numeric States:

- Can maintain current position
- Can transition to next lower value
- Can revert to Class 11 while preserving current state

From Class 11:

- Can only move to Class 10
- Can return to previously recorded numeric state



Conclusions

Key Achievements:

- Successfully demonstrated machine learning-based parturition prediction across the 4 different approaches

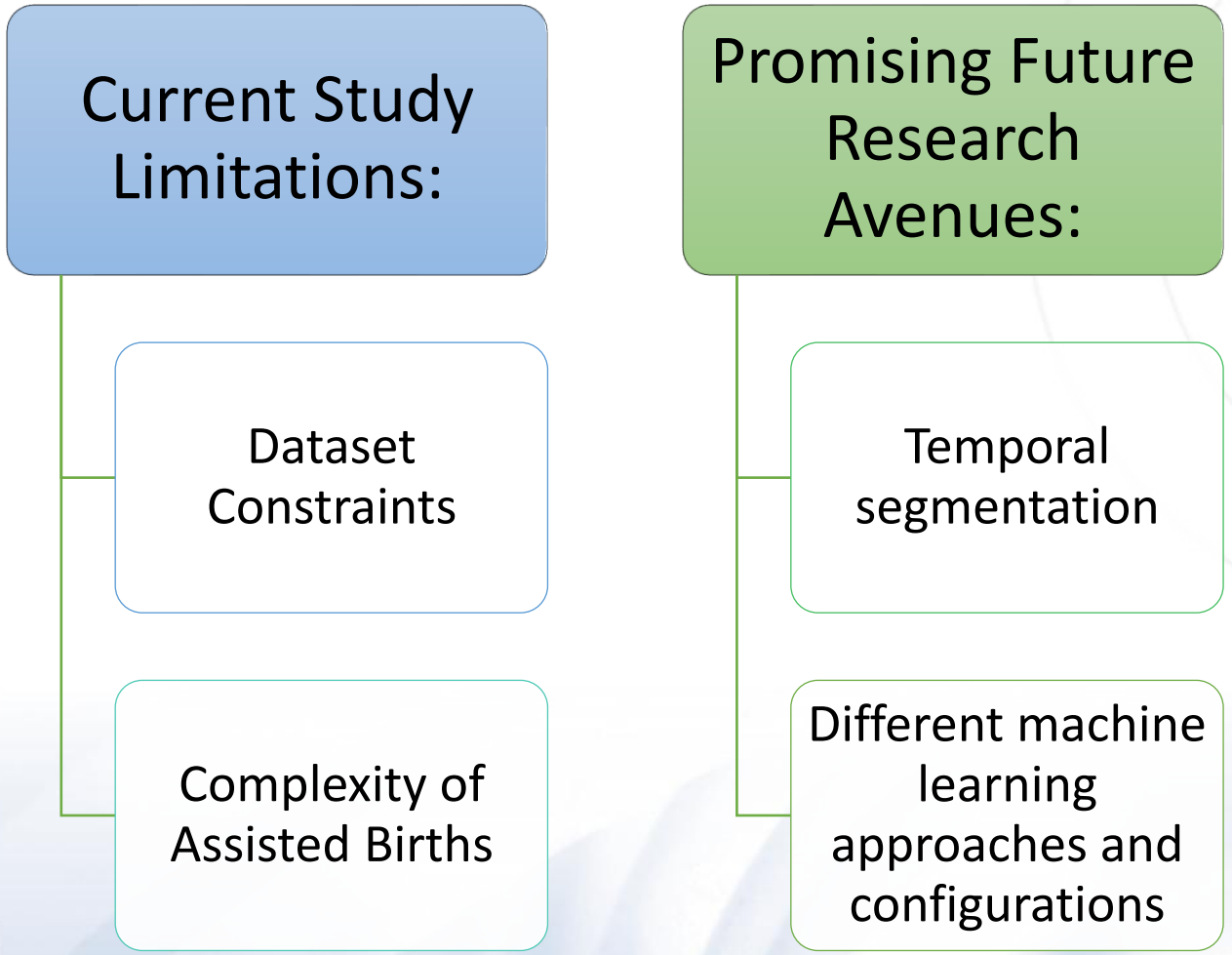
Significant Innovations:

- Early detection of parturition events

Current Study Limitations:

- Dataset Constraints
- Complexity of Assisted Births

Limitations & Future Work



Thank you

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