Automated Detection of Lameness in Animals using ML and Fog Computing approaches

Need of Lameness Detection

- Reduced reproductive efficiency, milk production and increased culling.
- 20 in every 100 cows are be affected by lameness in a given year on average in an Irish farm as reported by Ger.
- Lameness in sheep is the biggest cause of concern regarding poor health and welfare among sheep producing countries.
- Lameness is mostly detected at advanced stage and thus requires immediate and often costly treatment.
- Health, welfare and production performance on farms can be improved by early detection and prompt treatment of diseased animals.

Existing Approaches to Detect Lameness

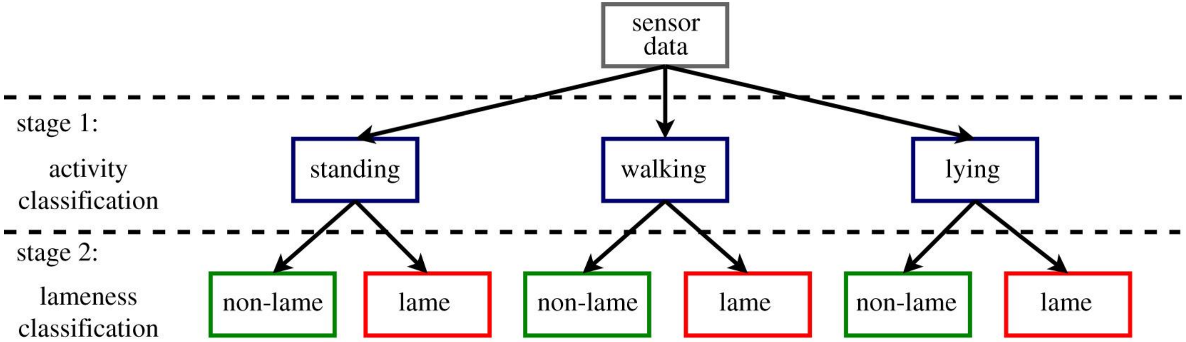
- Although most farms are equipped with some kind of lameness detection system based on accelerometers. Each of the system would require its own hardware.
- Most of the solutions are not accessible due to vendor lock-in.
- Image processing, Activity based techniques and Data Analytics have been in use with the assumption that all the animals will get lame the same way irrespective of factors such as season, location,etc.
- These methods use only cloud based analytics without leveraging and efficiently utilizing the resource which is not a useful system in the case of dairy cows where they need a regular check.

Proposed Work

- Compare algorithms that can differentiate lameness within three different activities (walking, standing and lying).
- 23 datasets (10 non-lame and 13 lame sheep) from an **accelerometer and gyroscope-based** ear sensor with a sampling frequency of 16 Hz is provided.
- Accelerometer and Gyroscope-based features ranked among the top 10 features for classification
- The sample dataset contains the 32 feature characteristics collected over the gap of 7s.
- Sheep profiling to be done based on LMS score into two categories Lame and Non-Lame.
- Ultimate goal is to classify lameness in sheep across a range of daily activities (walking, standing and lying).

Data Processing

- Classified the sheep firstly on the basis of walking, standing and lying. Once a sheep's activity was identified, a second classifier was applied in order to classify if a sheep is lame or not.



- Further applied a feature selection process to order and rank features according to their importance. Feature selection is carried out using a filter-based approach using ReliefF.

Model used for Classification

- Classification algorithms used to identify lameness were **Random Forest** (**RF**) and **K-nearest neighbours**(**KNN**) using the scikit learn package.
- In RF Algorithm, number of trees is set to 250.
- For the KNN, k is set to 5 with Euclidean distance metric.
- An individual classifier model was developed within each of the different activities (walking, standing and lying).
- Classification performance was evaluated using 10-fold cross-validation.
- In each fold, the performance of the model built on the training set is evaluated using the test sets.

Performance of the Classification

$$\text{overall accuracy} = \frac{\mathrm{TP} + \mathrm{TN}}{\mathrm{TP} + \mathrm{TN} + \mathrm{FP} + \mathrm{FN}},$$

$$\text{precision} = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FP}},$$

$$\text{recall} = \frac{\mathrm{TP}}{\mathrm{TP} + \mathrm{FN}},$$

$$F - \text{score} = 2 \times \frac{\text{precision} \times \text{recall}}{\text{precision} + \text{recall}}$$

$$\text{and} \qquad \text{specificity} = \frac{\mathrm{TN}}{\mathrm{TN} + \mathrm{FP}},$$

- TP (true positives) - number of instances where lameness was correctly classified by the algorithm.
- FN (false negatives) - number of instances where lameness was visually observed, but was incorrectly classified as non-lame by the algorithm.
- FP (false positives)- number of instances predicted as lame by the algorithm but observed as non-lame.
- TN (true negatives) - number of instances where the algorithm correctly classified a sample as non-lame when it was actually observed as non-lame.
- *F*-score - measure of a test's accuracy and is the harmonic mean of precision and recall.

RESULTS

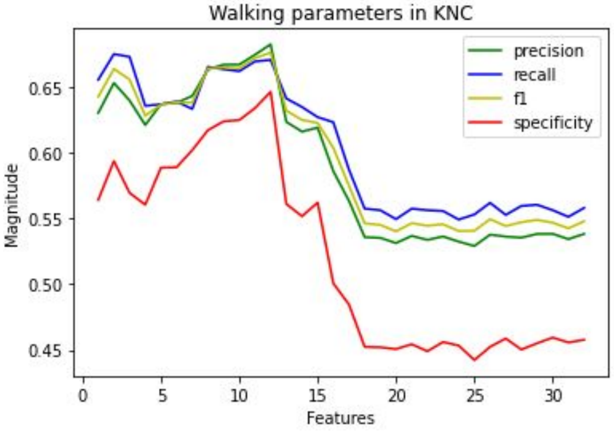
Source code link - https://github.com/chanmol1999/LamenessDetection

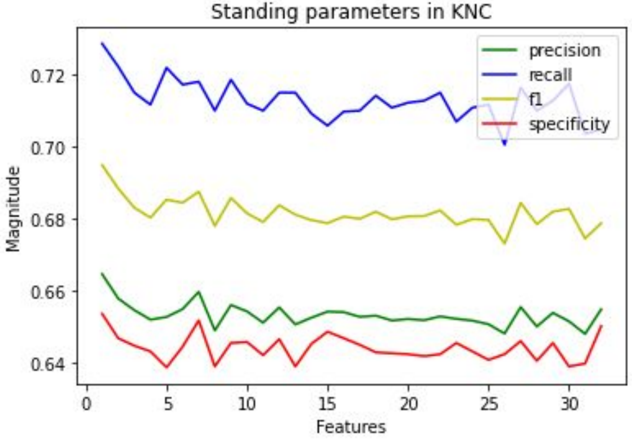
Google Colab Link
https://colab.research.google.com/drive/1UxDmLAupk2b1VM36bxP7v2Qb-fPCfLFf?usp=sharing

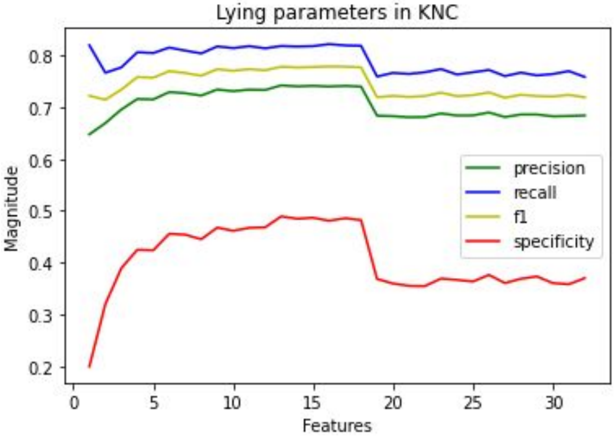
Facts Collected from Dataset

- Non-Lame sheepids identified - 1,2,3,4,10,11,12,15,16.
- Lame sheepids identified- 6,7,8,9,13,18.
- Data given in the discrete form of the days such as 1,6,7,14,17,31 accordingly for lame and non-lame each is mean of 7s duration.
- Classification of the dataset into lame and non-lame profiles on the basis of LMS score where 0,1 for non-lame and 2,3 for lame animal.
- Currently only the accelerometer and gyrometer have been used for classification which results into 32 feature characteristics i.e., 16 from each.

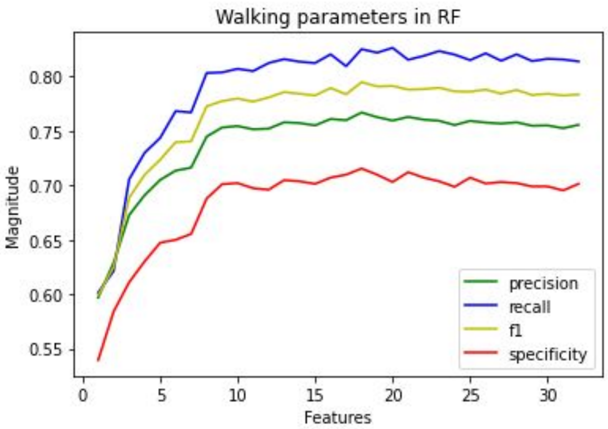
KNN Algorithm Performance across Activities

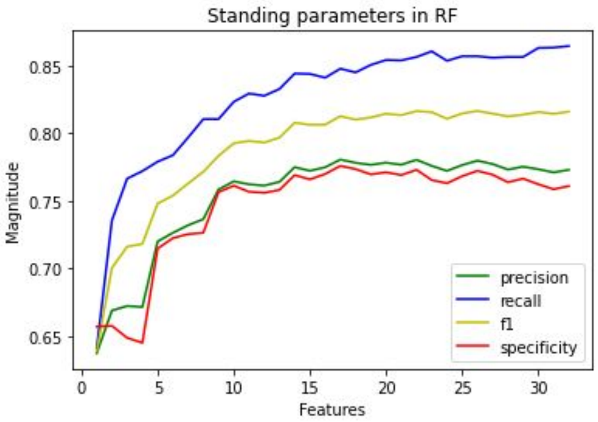


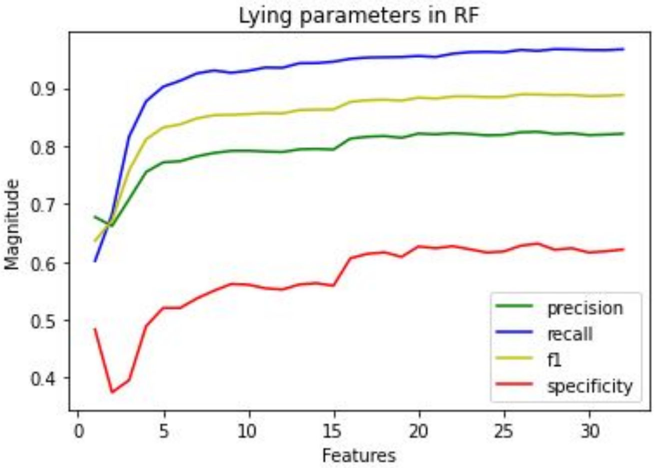




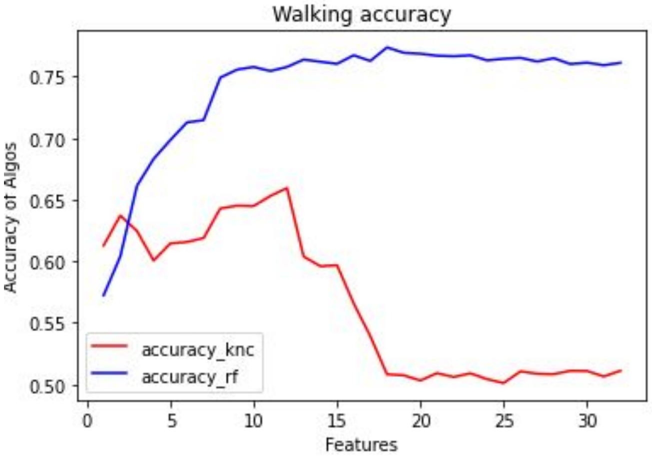
RF Algorithm Performance across Activities

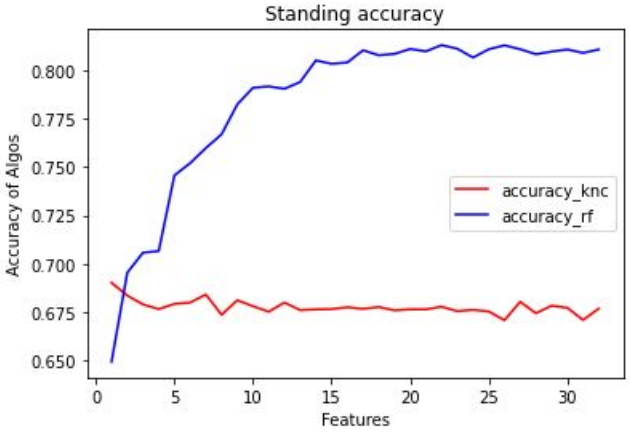


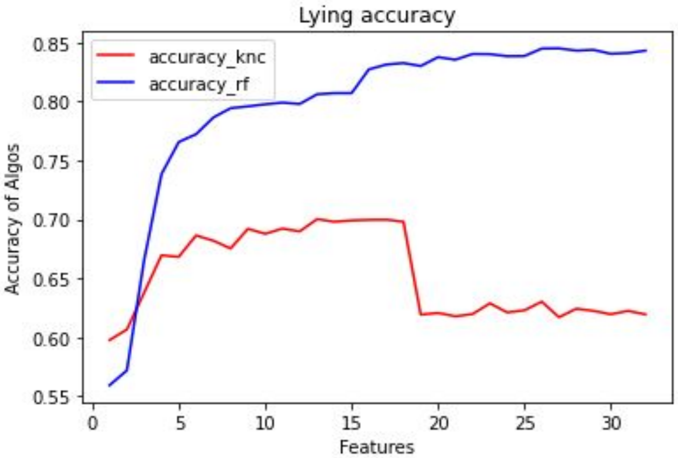




Comparison of Accuracy of Algorithms across Activities

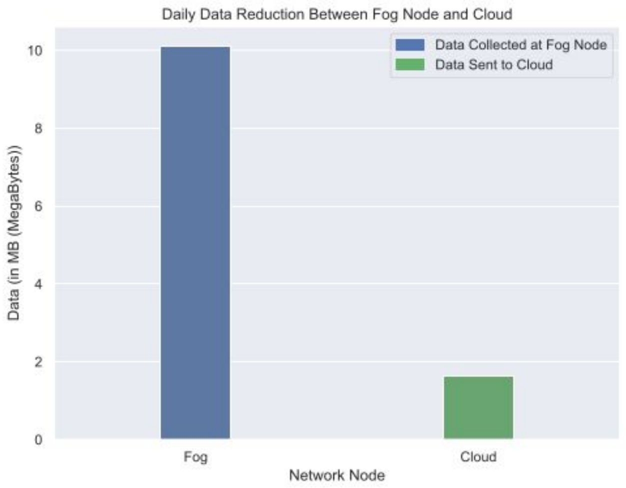






Inclusion of FOG Computing

- We observed that on average our model had an accuracy of 80-85%.
- So now only that data needs to be sent to the cloud that contradicts our prediction and needs further processing, i.e. through this approach we reduced data transfer to cloud.



Advantages Through FOG Computing

- With this approach we can build custom models for small groups of animals in the herd that share similar features within the herd.
- This improves the accuracy of the lameness detection as opposed to a one-size fits all approach which is practically not possible due to various factors such as location.
- Fog-based computational assistance enables the intelligent processing of data closer to the source, thereby leading to an 80-85% reduction in the amount of data transfer to cloud.

Fog Computing over Cloud computing

- The use of fog computing brings efficiency and sustainability to the overall IoT solution being proposed.
- In most cases, farms are located in remote locations and can suffer from phases of low or **no Internet** network connectivity.
- Fog computing aims to bring computation capabilities closer to the source of data thus reducing the **latency**.
- The fog computing based approach also leads to **effective utilization** of limited available resources.
- Significant reduction in the amount of the data being transferred to the cloud. Much of the data get **pre processed** in the fog node.

Future Work

- An ML model has been developed with the pre-processing of the data which ultimately depends on the local animal characteristics collected through IOT devices.
- Goal of the project involves deploying the model at a fog node after training **offloading** it into the cloud and only relevant information will be stored at the fog.
- Fog will serve as a **pre processing and analysis** unit.
- An **app** to notify farmers regarding lame animals making it less dependent to internet connectivity.
- Distributed data analytics, Distributed learning and Robust clustering can be the future for this technique.

References :

- Mohit Taneja, John Byabazaire, Nikita Jalodia, Alan Davy, Cristian Olariu,Paul Malone, 2020. *Machine learning based fog computing assisted data-driven approach for early lameness detection in dairy cattle*. www.elsevier.com/locate/compag
- Jasmeet Kaler, Jurgen Mitsch, Jorge A. Vázquez-Diosdado, Nicola Bollard, Tania Dottorini and Keith A. Ellis,15 Jan 2020. *Automated detection of lameness in sheep using machine learning approaches: novel insights into behavioural differences among lame and non-lame sheep.*https://doi.org/10.1098/rsos.190824
- Miiaková, M., Strapák, P., Szencziová, I., Strapáková, E., Hanušovský, O., 2018. *Several methods of Estrus detection in cattle dams: a review. Acta Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis 66(2),619–625.* https://www.researchgate.net/publication/324902783_Several_Methods_of_Estrus_Detection_in_Cattle_Dams_A_Review https://acta.mendelu.cz/66/2/0619/https://doi.org/10.11118/actaun201866020619
- Van Nuffel, A., Zwertvaegher, I., Van Weyenberg, S., Pastell, M., Thorup, V.M., Bahr, C., Sonck, B., Saeys, W., 2015. *Lameness detection in dairy cows: Part 2. Use of sensors to automatically register changes in locomotion or behavior. Animals.* https://doi.org/10.3390/ani5030388.
- https://towardsdatascience.com/an-implementation-and-explanation-of-the-random-forest-in-python-77bf308a9b76

Supervisor - Dr. Sudhir Kumar

Mentor - Mohit

PREPARED BY

ANMOL CHADDHA

1801EE07

B.TECH. ELECTRICAL ENGINEERING, IIT PATNA

(BATCH OF 2022)