

# Use of a precision-livestock-farming technology coupled with time series methods to identify abnormal circadian pattern of activity.

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The time-budget of animals and the circadian rhythm of activity are disrupted under stress, disease, or specific physiological states like estrus. Today precision livestock farming technologies (PLF) can automatically monitor several characteristics, including the activity of animals. For instance, with a Real-Time Locating Systems (RTLS) it is possible to infer the behavior of a cow from its location in a barn, and this can be done on a large scale, i.e. many animals for extended periods with a virtually continuous sampling. This opens the way to the use of behavioral indices to finely manage animals. Indeed, [1] designed a model of circadian rhythm of activity of cows using RTLS data. They show that average level of activity of a cow on a given day and its variations during that day differs with specific states (estrus, lameness, mastitis). Moreover, the circadian rhythm fluctuation in activity appear to be particularly sensitive and vary from 1 to 2 days before the disorder is observed by the farmer.

We studied positioning data coming from a UWB-RTLS system (CowView, GEA) installed at INRA experimental unit Herbipole (UE 1414, approved by the French Ministry for Agriculture). From the position and movement of the animal, its gross activity is inferred: resting if in cubicles, feeding if near the trough, and standing or moving in alleys. The dataset corresponds to the information from cows for two months. It provides for each cow the time spent to rest, to feed, to walk and to stand up per hour. The four values are merged into an activity level by applying a weighted average calculated according to the method proposed in [1]. The weights are rest, -0.34; feed, +0.52; walk, +0.29; stand up, +0.29. We considered the circadian activity of a cow as a time series in order to identify patterns specific to diseases or estrus and to identify the onset of such states. Time series analysis includes powerful tools such as clustering and classification methods. It enables to detect anomalies as well as forecast the future [2].

We split our dataset in two parts. The first part was composed of usual activities and is called the training-set. Here the cows had never been observed by the caretakers as sick or in estrus. The training-set was used to learn the parameters of a regression model that describes the normal activity of a cow. We tested several statistical models (ARIMA) [2] and machine learning models (neural networks e.g. MultiLayer Perceptron (MLP) [3], Support Vector Regression, decision tree for regression, lazy models, etc.).

The second set is called the test-set and contains usual and unusual activities (e.g. days where cows had been noticed as sick or unusual events occurred). The learnt regression model employs the test-set to predict the next hour of a cow's activity as if it was usual. To detect anomalies, we computed the difference between the predicted values and the observed ones (prediction error). If it was significant, we consider this period as abnormal.

We compared the models according to several criteria such as the prediction error and the quality of detection for a particular disorder. We introduced other criteria that are required in practice such as the training time, the robustness of the model to noisy labels and the ability to be deployed on various farms.

Some results are illustrated on Figure 1 for one cow and 8 days. Here an anomaly was detected that coincided with a test of the fire alarm in the barn, which apparently disrupted the activity of the cow.

The first tested methods, such as the MLP, show promising results concerning detection of irregularities. We can obtain a real-time detection for each hour or for each day. At present, the method is linked to the data we collected. In the future, we will extend our work by testing larger datasets and other farms, in order to check the adaptability of the regression methods can be deployed in other settings. If this is successful, we will propose ways to automatize the detection of irregularities and possibly relate the type of irregularity to a specific disorder.

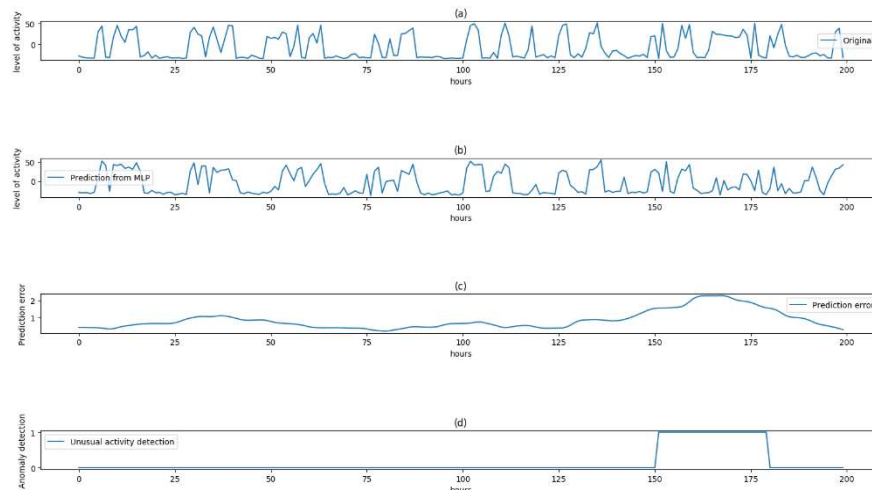


Figure 1: (a), original time series; (b), predicted time series; (c), prediction error; (d), anomaly detected (0, normal; 1, abnormal)

## Ethical statement

We did not modify any practice on the farm. All data that we processed were routinely collected without any intervention on animals. There is thus no ethical issues in our study.

## References

1. Veissier, I., Mialon, M.M., Sloth K.H. (2017). Early modification of the circadian organization of cow activity in relation to disease or estrus. *Journal of dairy science* **100**: 3969-3974.
2. Adhikari, R., Agrawal, R.K. (2013). An introductory study on time series modeling and forecasting. LAP LAMBERT Academic Publishing.
3. Gardner, M.W., Dorling, S.R. (1998). Artificial neural networks (the multilayer perceptron) – a review of applications in the atmospheric sciences. *Atmospheric environment* **32**: 2627-2636.