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Kévin Fauvel, Véronique Masson, Philippe Faverdin, Alexandre Termier

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head length. Slightly lower accuracy is achieved when analyses are carried out on high aspect ratio body shapes or on purely three-dimensional shapes, as found in the cases of average height or chest girth data comparison (with an $R^2=0.7-0.9$). The lowest performances are observed when parameter values are estimated as a combination of multiple parameters, due to uncertainty propagation: this has been shown in the cases of back slope or depth experiments ($R^2<0.5$).

Furthermore, compared to manual measurements, the adoption of the Kinect sensor for the quantification of body parameters allows a significant reduction in the absolute error means. Indeed, compared to the use of manual measurements, the non-contact Kinect approach enables the collection of more data in a shorter time and is not affected by difficulties associated with ruler reading or uncertainties related to

animal movements that are characteristic of slow manual measurement approaches.

The method clearly needs pre-industrialisation engineering activity to allow automatic data collection and extraction. Additionally, studies are needed in livestock environments to understand the effects of prolonged dust exposure on the Kinect infrared projector or sensor, and the presence of high vibration levels due to the frequent passage of tractors or other vehicles in the proximity of the device installation.

However, considering that livestock farms are generally increasing their stock densities, the possibility of replacing manual with non-contact measurements is of great interest in order to optimise herd management based on individual animal's health, welfare and growth data monitoring, with no induced stress on animals.

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Please contact:

Andrea Pezzuolo
Department of Agroforestry and Landscape, University of Padua - Italy.
andrea.pezzuolo@unipd.it

Data Science Techniques for Sustainable Dairy Management

by Kevin Fauvel (Inria), Véronique Masson (Univ. Rennes), Philippe Faverdin (INRA) and Alexandre Termier (Univ. Rennes)

A multi-disciplinary team of experts from Inria and INRA are working towards improving farmers' income and working conditions in an environmentally friendly manner.

As underlined in the last EU Agricultural Outlook 2017-2030 of the European Commission, growing global and EU demand is expected to support world dairy markets in the long term. However, farm economic viability encourages an increasing herd size. As a response, precision livestock farming (PLF) is a way to improve farm economic performance [1]. PLF is the use of continuous information to optimise individualised animal management. In addition, studies reveal that PLF can help enhance animal welfare [2], environmental sustainability [2] and working conditions [3].

Dairy Management

In dairy farming, data is collected through different types of sensors based on animals (e.g., temperature, accelerometer, feed intake, weight), buildings (e.g., temperature, humidity) or milking robots (e.g., volume, milk

composition). These sensors are common in today's farms and facilitate activity reporting.

However, the level of data analysis provided does not allow the farmer to make a decision such as inseminate or give medical treatment. Indeed, alerts from current devices often contain too many false positives to be reliable and the level of detail is too high to reduce the workload. For example, false positives for disease detection may result in extra medical treatment and monitoring costs, the inverse of the initial intent. Another key management aspect is heat detection for insemination purposes. It is fundamental because a cow must have a calf to begin lactating and is expected to give birth once a year thereafter to maintain a certain level of production. Thus, false positives for ovulation phase detection can lead to suboptimal production, additional semen costs and

decisions to cull cows due to reproductive problems.

Research Project

Current techniques used by animal scientists focus mostly on mono-sensor approaches (e.g., accelerometer), which are often insufficient to reduce false positives and ease decision-making. For specific diagnostics such as ovulation detection, there exist efficient mono-sensor approaches such as progesterone dosage in milk. However, such technologies remain too expensive for a massive implementation in dairy farming.

Our goal is to use widespread sensors to provide reliable recommendations to facilitate farmers' decision-making about insemination, disease detection and animal selection. Our aim is to combine common sensors in dairy management (e.g., accelerometer and temperature) in order to diagnose events



Figure 1: A cow equipped with an activity meter.

and elaborate upon these recommendations. This problem structure requires the use of machine learning methods. Thanks to an experimental farm, labeled data is available. The challenge is to design new algorithms which take into account data heterogeneity, both owing to their nature (e.g., temperature, weight, feed intake) and time scales (e.g., each five minutes, twice a day, daily).

Indeed, our approach will rely on multivariate time series classification and no existing method is designed to efficiently handle data having different time scales per dimension. First, most methods are

window based: they extract features with the same temporal granularity per variable. Then, among methods specific to each variable properties, no exhaustive and efficient way to characterise different events has emerged.

The goal is to provide solutions to be transferred to the agricultural sector. This work is led by Inria LACODAM and INRA PEGASE teams in France under the #DigitAg initiative. #DigitAg is the French Digital Agriculture Convergence Lab, which brings together 360 researchers and higher education teachers from leading French organisa-

tions in this field. It is supported by the French state through the National Agency for Research funding with the reference ANR-16-CONV-0004.

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Please contact:

Kevin Fauvel, Inria, France
kevin.fauvel@inria.fr

Alexandre Termier, Univ. Rennes, France
alexandre.termier@inria.fr

Measuring Micro-climate to Create Disease Prediction Models

by Christian Hirsch (TU Wien)

In crop production there are still many diseases where the time of infection and outbreak in connection with the weather is still not known. Some farmers have weather stations in their fields to monitor weather conditions in order to prevent a possible spread of a disease. However, the measurements of the weather stations represent the climate within an area of several 100 m². To overcome this problem, TU Wien and BOKU Wien are preparing an IoT infrastructure to measure micro-climate in vineyards. Many sensors are placed all over the field and the collected data will be used to create disease prediction models using machine learning algorithms.

In addition to natural disasters, crop diseases are still a major risk to crop yields in agriculture. Some diseases are already well known and studied, and there are models for these diseases that can tell a farmer the risk of its occurrence based on weather information and weather forecast. With this information the farmer is able to take steps to protect the crops right on time. However, the main causes of other diseases are still unclear, making it difficult for farmers to take steps to protect their crops. One of these diseases is the powdery mildew in vineyards.

Many fields and vineyards, used for educational and scientific purposes, are

equipped with weather stations. These stations typically measure wind, precipitation, humidity, temperature and leaf wetness. The problem, however, is that the measurements of a weather station represent a whole field of several 100 m², making it impossible to detect micro-climate changes that might trigger a certain disease. To overcome this problem, TU Wien [L1] and the University of Natural Resources and Life Sciences, Vienna (BOKU Wien) [L2] will set up an Internet of Things (IoT) infrastructure consisting of small battery powered sensors [L3]. Like the weather station, the sensors will measure humidity and temperature.

Additionally sensors for atmospheric pressure, soil moisture, soil temperature and CO₂ equivalents will be deployed. Many sensors of the same kind will be used and placed all over the field, enabling the scientists to record climate differences within a field.

The IoT infrastructure will consist of three basic parts: the swarm (Figure 1a), the fog (Figure 1b) and the cloud (Figure 1c). The swarm represents the set of sensors used to measure micro-climate. Typically those swarm nodes use wireless means of communication with a base station or GSM. The nodes are normally also equipped with a