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ScienceDirect

Procedia Computer Science 110 (2017) 110–116

Procedia Computer Science

www.elsevier.com/locate/procedia

The 14th International Conference on Mobile Systems and Pervasive Computing (MobiSPC 2017)

Web-based cattle behavior service for researchers based on the smartphone inertial central

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Abstract

Smartphones, particularly iPhones, can be relevant instruments for researchers in animal behavior because they are readily available on the planet, contain many sensors and require no hardware development. They are equipped with high performance inertial measurement units (IMU) and absolute positioning systems analyzing users' movements, but they can easily be diverted to analyze likewise the behaviors of domestic animals such as cattle. The study of animal behavior using smartphones requires the storage of many high frequency variables from a large number of individuals and their processing through various relevant variables combinations for modeling and decision-making. Transferring, storing, treating and sharing such an amount of data is a big challenge. In this paper, a lambda cloud architecture and a scientific sharing platform used to archive and process high-frequency data are proposed. An application to the study of cattle behavior on pasture on the basis of the data recorded with the IMU of iPhones 4S is exemplified. The package comes also with a web interface to encode the actual behavior observed on videos and to synchronize observations with the sensor signals. Finally, the use of fog computing on the iPhone reduced by 42% on average the size of the raw data by eliminating redundancies.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: precision livestock farming; smart breeding; smart agriculture; database; intertial unit; webservice; Internet of things; animal behavior; classification algorithms

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1877-0509
Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2017.06.127

1. Introduction

The use of sensors in livestock farming is becoming widespread, especially in dairy cattle operations. Most methods suggested to treat the data collected to analyze the feeding behavior of cows use black-box type models and reach accuracies as high as 90% of correctly classified behaviors[1]. According to the literature, three main components are required to analyze the behavior of animals: (1) location obtained by radio frequency triangulation or by global positioning system (GPS), (2) low frequency component of behavior as posture of the animal (e.g.: position of the head, tilt of the neck, etc.), (3) high frequency component of behavior (e.g. movement of the jaws)[5]. Recently, the use of smartphones, particularly iPhones, was suggested for this purpose[1] as they are readily available on the planet, contain many relevant sensors and require no hardware development. They are equipped with high performance inertial measurement units (IMU) and absolute positioning systems that can easily be diverted to investigate the feeding behaviors of cows under a range of environmental conditions. Such researches aiming to the development of precision livestock farming (PLF) applications, i.e. shifting from the management of a herd to the individual management of the animals in the herd, require the collection of many data in real or near real time and the setting up of a dedicated computer infrastructure. This infrastructure, in addition to data collection, should allow researchers to share their datasets and models. To fulfill this goal, the experimental data must be consistently structured in order to facilitate the exchange. Using data collectively will enable the development and the validation of new models from larger datasets and provide new research opportunities for animal feeding behavior and health as well as pasture management. This will also pave the way to PLF by allowing parameter identification or combination and the sampling frequencies that are required to accurately detect specific behaviors, and the development of specific, accurate and reliable connected sensors. Indeed, the Internet of the things will offer tremendous opportunities in PLF by making it possible to know at any moment the health status of the animals and to detect problems before they become worse. For this purpose, using connected sensors in association with cloud technologies for research and later routinely in the farms poses a double challenge. Firstly, at the level of the sensors, data must be collected at a high-frequency (up to 100 Hz) and processed to eliminate redundancy. The reduction in data size is essential to reduce bandwidth requirements for transmission and improve battery life. Indeed, sensors are generally powered by external batteries whose main sources of consumption are the network transmissions. The second challenge is the storage and the processing of large amounts of data per animal per day (from several tera to several peta bytes) arriving at high speed at the cloud level.

The collection of data for a large number of cows in different environments around the world is a corner stone in the development of new models and their validation on large data sets. Moreover, in order to allow farmers to benefit from these new technologies, the development of a new set of microcontrollers sensors will be necessary. The sensor will be optimized on the basis of the results of the research previously mentioned to collect essential information at the adapted frequency in order to identify behavior with high accuracy. The new sensors need also to be optimized in order to reduce power consumption through local processing of information and a limit transmission of information through the network. Finally, data related to breeding conditions, animal performances and health may be sensitive and require protective measures, by anonymizing and controlling their use.

In this paper, we present a chain of tools fulfilling the above-mentioned criteria for data related to cattle behavior measured by means of the IMU signals of I-phones worn by the animals on halters[6]. We propose and describe a new infrastructure allowing to collect, store, treat and share information between scientists. The sharing of important amount of data is important to create more robust models and (re)validate existing models. The proposed lambda architecture brings benefits in storage, real-time processing and abilities for large scale data storage and analytics.

2. Literature review

Large-scale data collection and sharing requires a cloud storage platform to standardize, store and exchange data. This kind of platform could be used to develop, test and validate new models analyzing animals behavior and the relevant signals to be recorded. When the amount of data is large and diversified enough, the most relevant parameters used to detect a given behavior can be identified. The best sampling frequencies can also be extracted in