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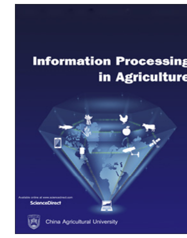

Modelling the smart farm

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ABSTRACT

Smart farming envisages the harnessing of Information and Communication Technologies as an enabler of more efficient, productive, and profitable farming enterprises. Such technologies do not suffice on their own; rather they must be judiciously combined to deliver meaningful information in near real-time. Decision-support tools incorporating models of disparate farming activities, either on their own or in combination with other models, offer one popular approach; exemplars include GPFARM, APSIM, GRAZPLAN amongst many others. Such models tend to be generic in nature and their adoption by individual farmers is minimal. Smart technologies offer an opportunity to remedy this situation; *farm-specific* models that can reflect near real-time events become tractable using such technologies. Research on the development, and application of farm-specific models is at a very early stage. This paper thus presents an overview of models within the farming enterprise; it then reviews the state-of the art in smart technologies that promise to enable a new generation of enterprise-specific models that will underpin future smart farming enterprises.

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1. Introduction

Various initiatives in the domain of smart farming have been documented; examples include SmartAgriFood,[1] the Dutch Smart Dairy Framing project,[2] EU Precision Livestock Farming (EU-PLF),[3] and Cow of the Future.[4] Though particular objectives vary, the overriding objective is that of efficiency. Information and Communication Technologies (ICTs) offers great potential for improving efficiency, effectiveness and productivity; nonetheless, they remain underutilised in agriculture [1]. Small changes in production or efficiency can have a major impact on profitability [2]; from a sustainability perspective, this may, counter-intuitively perhaps, result in a reduction in output. Fundamental to efficiency is the *effective* capture, processing, management and visualisation of many heterogeneous sources of information so as to enable economically-viable and environment-friendly decision-making. Enabling such decision-making is problematic, not only as a consequence of the variety of information available but also due to the dynamic nature of the many variables necessary for strategic planning and optimal decision making.

Ongoing developments in ICT offers significant potential to manage information at the farm level. Sensing technologies, at least in principle, offer farmers the ability to monitor their farms with an unprecedented level of detail, in a multiplicity of dimensions and in near real-time. This offers an intriguing possibility of developing *farm-specific models* that the individual farmer can use to plan their activities in response to changing circumstances, thus enabling the exploration of the various trade-offs inherent in any decision-making process whilst managing the information overload problem. For the remainder of this paper, developments in modelling are explored, and the technologies necessary to enable the construction of farm-specific models considered.

2. Sustainable intensification

Reconciling sustainability with productivity, economic factors, and environmental impact is a formidable challenge; nonetheless, maintaining current agricultural practices will have negative effects on global food production [3]. Three theoretical limits within which agriculture must operate include [4]:

1. quantity of food that can be produced within a given climate;
2. quantity of food demanded by a growing economically changing population, and
3. impact of food production on the environment.

Ultimately, environmental impact depends on how global agriculture expands in response to rising demand [5]. Agricultural intensification has reduced the carbon footprint per agricultural product; this process is expected to continue [6]. Sustainable agriculture seeks to maximize the net benefits that society receives from agricultural production, demanding amongst others, major changes in livestock production practices [7]. Sustainable Intensification, a more recent and fluid construct, seeks to increase food production while minimizing pressure on the environment, and is a specific policy goal for certain institutions [8]. Transition towards more productive livestock production, in combination with other climate policies, for example, represents, potentially, an effective mechanism for delivering desirable climate and food-availability outcomes [9]. Thus, from a practical livestock farming perspective, identification of the most efficient animals and feed systems is a prerequisite for sustainable livestock intensification programs; system modelling is viewed as a key enabling tool [10].

2.1. Agricultural domain modelling

Modelling techniques have been harnessed in a wide variety of agricultural domains (Fig. 1); these include high-resolution field maps of soil properties [11], pasture growth rate [12], greenhouse gas emissions [13] amongst others. For animals, basic activity patterns can be quickly derived through the use of GPS-enabled collars [14,15]. More sophisticated models by which to infer behaviour may then be constructed using a variety of machine learning techniques

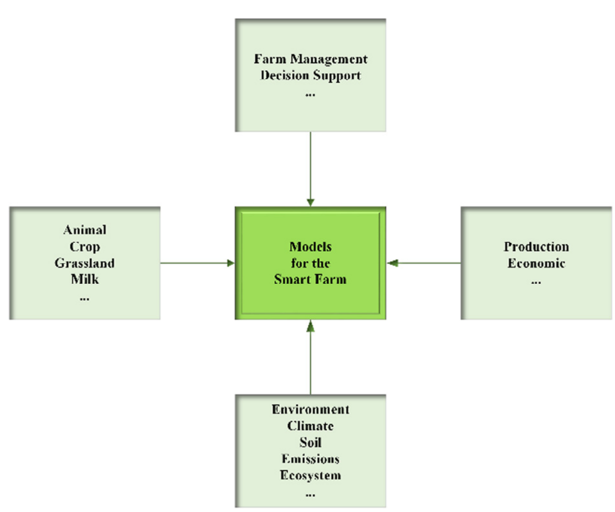

Fig. 1 – Models have been developed for many dimensions of the agricultural enterprise. Incorporating pertinent models whilst managing the trade-offs between complexity and usability is a key challenge for enabling a Smart Farm.

1 http://smartagrifood.com/.
2 http://www.smartdairyfarming.nl/nl/.
3 http://www.eu-plf.eu/.
4 http://www.usdairy.com/sustainability/for-farmers.