Chapter 8
Design and Modelling Approaches for Advanced Agricultural Fleet Management Systems

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ABSTRACT

Knowledge based management of the production is the key to future sustainable and rational agricultural production. The maximisation of the agricultural machine productivity is an important element in the continued efforts of planning and controlling resource input in agriculture. Current consensus depicts agricultural fleet management must adapt a hybrid architecture for the planning efforts with a combination of deliberative and reactive approaches. The transfer of methodologies from the established operations research area has proved beneficial to the planning of agricultural operations as part of a fleet management system. By using deliberated abstractions and representations, the specific planning of agricultural operations can be cast as instances of well-known operational research problems. In this way, the established well proved solution methodology from these problems can be seen to enhance agricultural field operations planning. Key requirements for an envisioned future fleet management system include a positive cost-benefit, flexibility in relation to specific applications of the system, a simple user interface requiring no heavy learning efforts, automatic data logging and data storage, integrations options with other internal management tools, and effective planning and optimisation algorithms adaptive to the actual on-the-farm conditions.

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INTRODUCTION

The structural changes and the externally imposed requirements on agriculture mandate the incorporation of innovative technology and knowledge management in future cash crop and high value crop farming. Especially, the maximisation of the agricultural machine productivity is an important element in the continuing efforts of planning and controlling the input of resources, such as energy and chemicals. An important step in achieving increased operational efficiency is the renewed focus on the usage of advanced information and communication technology (ICT) systems and formal management models in agriculture. In the long-run, research shows that there can be significant benefits in the paradigm shift from large machines to smaller and more intelligent multi-robot systems, which can establish and nurse, for example, plants at an individual level (Blackmore et al., 2005; Sørensen et al, 2005; Pedersen et al., 2006; Fountas et al., 2007). Such a development will increase the demand for advanced management tools, like fleet management tools for scheduling, monitoring and on-line coordination of numerous cooperating agricultural vehicles.

Fleet Management Systems have been commercially available in the industrial domain, e.g., the transport business, for a number of years. These systems have evolved into complete enterprise management tools linking together all parts of the enterprise (Crainic & Laporte, 1998; Miele, 2005). The new trend clearly dictates increased management sophistication in terms of turning such tools into comprehensive and operational planning tools (van Heijden & Marchau, 2002). An extensive use of real-time data and wireless communications are envisioned together with increased intelligence for real-time planning, where industry developers identify those parameters as the primary drivers for the current development (Bernard *et al*., 2008).

Agriculture is currently seeing the introduction of more advanced machinery as well as information technology which enable the adoption of the analogous fleet management tools as seen in the industrial domain. However, the inherent biological and dynamic nature of agricultural operations together with an experienced smaller general user acceptance in terms of formalised planning models have proven to inhibit a habitual transferable and integration of current fleet management systems into the agricultural domain (Sørensen and Bochtis, 2010). Farmers, in general, both generate and execute any plan made, and their decision making process associated with the planning remains very much implicit and internal. As a result, in agriculture there is only a sparse tradition for using formalised planning tools and adopting advanced optimisation methods from the operational research area.

An example from the operational research domain is the vehicle routing problem (VRP). The VRP has been characterised as one of the great success stories of operational research, providing and facilitating, for over fifty years, optimal planning solutions for vehicle fleets in a large number of real-life applications (Toth and Vigo, 2002). Despite the fact that almost all agricultural field operations inherently involve the motion of vehicles, the VRP problem has only very recently been implemented for the planning and execution of in-field operations involving agricultural machinery.

In the following, after a short review on the most recent research regarding the management of agricultural machinery fleet systems, a classification of agricultural field operations is devised tailored to a conceptual application of advanced route planning methods developed in operational research disciplines within the domain of agricultural field logistics. In the next section, two example of modelling of agricultural field operations as VRP instances using the appropriate abstractive representations are presented. The implementation of the plans generated by the described approaches requires corresponding communication systems. In the next section, the

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