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Towards automated compliance checking based on a formal representation of agricultural production standards

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ABSTRACT

Production standards in the form of legal regulations or quality assurance labels are playing an increasingly important role in farming. Each farm must therefore gather information on all standards which apply, which may vary from field-to-field, and ensure that they are respected during operations. This information may be provided on paper or as electronic documents, by the standards publishers or by advisors. Together with the need to document compliance, the need to collect and process the requirements is becoming increasingly burdensome for farmers.

In this paper, two questions are addressed: whether an automation of the compliance checking is possible, in order to assist the farmer by proactively warning against 'forbidden' operations, and how the definition of the production standard may be formally represented in order to clearly and unambiguously inform the farmer as to what is required. This formal representation also forms one of the prerequisites for any automated assessment.

As an initial step, a general model of production standards was developed and applied to some common standards in European agriculture. Based on this model, separating standards into metadata and a list of individual rules (check points), a formal representation was developed and an assessment was made as to whether an automated compliance check was feasible.

1. Introduction

Production and management standards are becoming increasingly important in agriculture: an increasing number of legal regulations to ensure food safety and agri-environmental good practice are binding for all farmers, whilst voluntary standards and labels to demonstrate compliance to stricter requirements and ultimately gain a higher price for agricultural produce are an important tool for farmers to market their products or enable them to sell to particular buyers and markets (Deaton, 2004, Jahn et al., 2005, Fulponi, 2006). Examples of legal regulations are laws affecting use of fertilisers, plant protection products, seed types, etc. Voluntary standards may be legally regulated, such as the EU Organic standard (EC Regulation 834/2007), or may be privately-run industry standard such as GlobalGAP (GlobalGAP, 2007). Adherence to particular standards may be motivated by direct financial benefits, such as subsidy payments, being linked to this, such as is the case with the European 'Cross-Compliance' regulations.

Each farm must potentially adhere to a large number of standards, and it is possible, or even likely, that different parts of the farm must be managed according to different standards, e.g. different crops being sold to different buyers who stipulate their own production standards, or parts of the farm falling in a specific area such as a water catchment protection area where tighter environmental regulations are enforced. Additionally, the laws applying to the farm vary according to the country or federal state, or in some cases even smaller administrative units. Each farm, or even each field or even partfield, must therefore be considered a potentially unique case in being managed according to a unique constellation of standards. Additionally, standards vary through time as new versions are produced.

Given this large number of different standards in use and the need for farmers to work with the correct standards, in the correct versions, active support from the farm software during the decision-making process in order to ensure that management decisions such as fertilisation and spraying plans conform to the relevant standards is desirable. The current procedure for assessing compliance to standards is typically that the farmer must document the correct completion of the procedures and actions as required by the standard. Additionally, some standards require that certain

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information is presented in a particular form. The documentation is then periodically audited, usually by an external certification body, together with an on-site inspection. The farmer must therefore understand what is required by the standard and take account of the requirements during the planning and performing of actions – this is frequently done through the use of self-assessments e.g. as checklists. The farmer must also be able to produce documentation to satisfy the certification body that they have met the requirements, and so should know in advance what is required, how it should be presented and integrate collection and management of required data in operational processes. Such a service is offered e.g. for common standards in use in Germany by KKL-Service (2010). This is however not integrated with the farmers' existing software, where farm data are already held, does not offer the possibility for automated assessment and is restricted to the standards which have been analysed and prepared by KKL.

This paper therefore addresses two research questions:

1. Whether an automatation of self-assessment of compliance to standards is feasible.
2. How standards may be formally represented in such a way that personalised checklists can be easily generated by farmers themselves and that the individual requirements defined by the standard are clearly and unambiguously defined such that they may potentially be interpreted by a machine.

In the next section, a general model for the composition of an agricultural production and management standard is presented. The analysis of whether compliance-checking may be automated, based on transforming existing standards to this model, follows. The formal encoding for standards is then introduced in three sections corresponding to parts of the general model of standards. Finally, there is some discussion regarding the work presented here and what developments may be necessary in order to improve the definitions of agricultural standards with respect to automated assessment and to enable their integration into agricultural software on an ad hoc basis.

2. Structure of agricultural standards

Based on the analysis of representative agricultural production and management standards, which were previously presented a general structural model of an agricultural standard, together with four criteria which must be met in order to enable automated compliance checking (Nash et al., 2009a,b). As these form the basis for the work presented here, they will be reviewed in detail.

An agricultural standard may be considered as being composed of a set of rules together with metadata describing the publisher, the intention of the publisher, the spatial and temporal range of validity, the target audience, procedures in the event of non-compliance, a definition of terms used. Additionally, each rule may have certain metadata attached to it regarding how compliance to that rule is to be assessed, and whether all rules must be complied with in order for the whole standard to be complied with or whether only a certain percentage of individual rules must be met. Each rule is effectively a predicate (i.e. a logical statement which may be evaluated to *true* or *false*), together with a conclusion (i.e. compliance or violation of the standard). Rules may be classified as either an obligation ('the standard is complied with only if the farmer does *x*'),) or a prohibition ('the standard is not complied with if the farmer does *y*'). Additionally, rules may require that particular actions are documented, whilst not proscribing how they should be performed. Although these may be considered as obligations, they are treated separately as they do not directly affect the decision-making related to field operations (e.g. the volume of nitrogen fertiliser to be applied). Individual rules may also be considered as having some metadata such as describing which operations they apply to, what data may be used to assess compliance etc. This model is presented graphically in Fig. 1.

Current agricultural standards are not explicitly presented in the structural form presented in Fig. 1; most legal regulations are presented as texts, whether paper or electronic, whilst in the best case the standard may be presented as a checklist of individual rules (e.g. GlobalGAP). Where the standard is presented as a text, the identification of individual rules may not be straightforward. Any standard can however be converted to the form specified by this model (Vatsanidou et al., 2009).

3. Determining the potential for automated assessment

In order to enable the automated assessment of each rule, four prerequisites must be met:

1. The rule must be encoded in a machine-readable form. This may be hard-coded as algorithms in the software or take the form of a transfer format (e.g. XML-based) which the software performing the assessment can read.

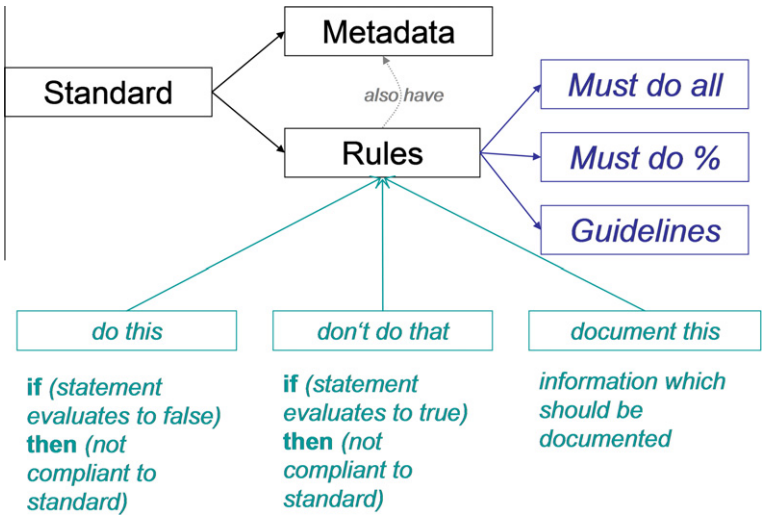

Fig. 1. General structural model of an agricultural standard.