

Management of huge amounts of data using qualitative and statistical modeling: an agricultural case study

Abstract

The increasing complexity of agricultural data and their management, in finding solutions for certain farmer's problems, requires adequate tools. Fortunately, developments in computer technology continually expand the possibilities in agricultural data analysis and processing. In this study, we tackle some of the important issues in agricultural data management and processing, using an integration of statistical tools and qualitative modeling techniques, in order to describe the complex structure of agricultural processes running in a specific cattle's breed scheme. Specific methodologies were used to make more efficient use of data collected by providing a means of effectively analyzing data. The implementation of the proposed approach is based mainly upon the use of object-oriented and visual development tools applied into the creation of an interactive and friendly computer environment for agricultural data management-as a practical example, where various data manipulation and analysis techniques, as well as experimentation and further research in cooperation with the farmer, can easily be contacted. The application system seems to be a very useful tool in organizing the information regarding agriculture, by providing important utilities offered by the new technology in the field of agriculture.

Keywords: database management, integrated environment, qualitative modeling, data processing

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Introduction

The approaches and methodologies used for agricultural data analysis and processing in general continuously evolve (e.g. specific statistical analysis methods and tools, such as SPSS, are used quite intensively to assist the researcher's work). The basic idea in our research work is to provide an integrated environment, where various data analysis and modeling tools would be at the disposal of the researcher to be used in processing farming production problems and extracting adequate solutions. For this purpose, certain database management and qualitative modeling techniques have been used in conjunction, as an integrated computing environment, called Agro-Model, and tested upon specific cattle breeding cases. Artificial intelligence and qualitative modeling techniques have been applied for a long period of time, with quite successful results in most of the cases.¹ However in the field of agriculture there is still a need for further research work to be carried out. We decided to use and apply qualitative techniques describing the structure and performance of plants and animals within agricultural environments, in order to assist the agriculturist to manage easily complicated processes, associated in particular with cattle breeding, and provide the ability to extract and evaluate the most valuable information from a set of complicated with various factors quantitative data. The retrieval of all the relevant information on the control treatments in various agricultural cases could be considered as a quite important research material for interesting studies of the plant species or livestock breeds in various experimental environments.

Material and methods

The overall application work was carried out using the above mentioned integrated environment Agro-Model and a qualitative modeling tool, called QMTOOL.² In our integrated approach, we used that qualitative modeling tool in conjunction with Agro-Model³

in order to produce working models of the agricultural process under control, and test them in order to acquire the desired functionality, prior to their farm implementation. The development of the integrated application environment of this study was based mainly upon the use of object-oriented and visual development tools, and the use of open architecture technology drivers and methods -ODBC interface, SQL-to interact initially with Microsoft Access and Excel databases and later on with certain statistical packages, such as SPSS, on a Windows 98 operating system platform.^{4,5} In particular software modules were created as V-Basic modules scripts and SQL queries in order to facilitate the communication of model components and execution of internal functions and procedures. The idea was to use an interactive and friendly environment for agricultural data management, where data analysis (e.g. statistical) and experimentation, as well as further research on contemporary data analysis techniques, could easily be contacted.

Results and discussion

In our case study, we used only a subset of real data (of Charolais Breed – from the MLC Beef Cattle huge recording scheme) extracted from that huge database to work with, as an example of farmer's level specific interest. It was important to find the tools to describe and analyze such agricultural data structures (cattle breeds and their characteristics), in order to specify and select the most adequate qualitative scheme, without an in-depth requirement for programming skills. It was also necessary to be flexible enough to allow easy modifications of the given data structure according to any new requirements. Using the facilities of the modeling tool mentioned above, system models were created by simply connecting input, state and output objects and assigning to their connections qualitative values of their magnitudes and relationships. During the execution phase, the system converts qualitative attributes into numerical data in order for the appropriate simulations calculations to take place. This

conversion is based on qualitative to numerical values conversion tables, describing basic numerical and alphanumeric factors such as herd's size, dam's category, etc in the selected Charolais breed data scheme.

The mapping of mathematical equations (interrelation of data variables), shown as objects connections between the input, state and output variables, into qualitative descriptions is carried out using the following functional: $M+(Invar, Stvar)$, $M-(Stvar, Stvar)$, $f(Stvar, Outvar)$ arithmetic: add, minus, etc. and derivative: incr, steady, decr, etc., constraints. The qualitative marks $M+$, $M-$ and f simply indicate that there is a relationship (influence), positive or negative (qualitative terms representing the magnitude of the functional relationship) between these variables. The actual value calculation of a given variable is based on its current value (state) plus a sum of influenced values of the preceding variables. A single influence is calculated taking into consideration the value of its predecessor and the magnitude of the connection expressed in qualitative terms. For instance, given that calf's quality factor (Cq) is in functional relationship with the Sire's and dam's class categories, this is expressed in the following way: Calf Quality: $f\{M+\{Sc\}, M+\{Dc\}\}$. Internally, qualitative modeling involves the interpretation and execution of such system's equations, based on qualitative methods for modeling physical systems.

As a general conclusion of the results presented could be realized that the degree to which a user could exploit the Agro-Model depends on his goal and his level of knowledge and experience. In cases of general database use, an elementarily trained farmer could accomplish his main management requirements; for a more educated researcher there are advanced tools, which could be exploited according to specific scientific purposes. We have addressed the problem of modeling and managing some of the important cattle breed characteristics, using a tool that utilizes both conventional numerical methods and more advanced qualitative techniques, in order to deal efficiently with proper animals' selections of the most productive ones. In particular, we were able to:

- a) Produce a reliable description of the specific cattle breed scheme based on qualitative models.
- b) Provide flexibility in the manipulation of various cattle parameters in qualitative forms during the model's design.
- c) Produce accurate results of cattle's behavior comparing to physical representations.

- d) Reduce the cost of cattle's management by reducing the risk of taking wrong selections decisions.

Qualitative models of the selected cattle's scheme were introduced at a high-level abstraction form, using relatively small amount of information, similar to human reasoning on studying complex physical system's behavior. This approach of the application system Agro-Model among its general importance in the agricultural industry as a whole (education, research and production), seems to be a very useful tool in organizing the information regarding agricultural data, while at the same time provides the utilities for the best exploitation of the knowledge gained up today in the field of conventional agriculture. This application environment tends to be improved and incorporate further agricultural data (plant and animal), as a broader biometrical agricultural network database, in order to provide a fully integrated environment where various conventional and sustainable agricultural data could be gathered for scientific studies and for practical purposes as well.

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Conflicts of interest

Author declares that there is no conflict of interest.

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