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A Methodology to allow Rural Extension Professionals to build Target-specific expert systems for Australian Rural Business Operators

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Abstract

Expert systems (ES) development technology has been used to build rural business applications in the past but these have usually been developed using traditional expert systems shells. This paper introduces a new architecture for the development of a design environment where the domain experts can build a knowledge base for target-specific ES for rural business operators. The system allows rural business operators to use their own knowledge in building their own, target-specific ES for tailored development to their own specific requirements. At this stage, this reusable design environment caters for the Australian dairy industry but in the long run we claim it will be useful for the other livestock based rural industries such as beef cattle and sheep. This approach of developing target-specific ES contributes new knowledge in that it provides a new way of developing decision support by allowing human domain experts to develop relevant ES for different livestock farming business.
An evolutionary prototyping approach was employed for initial development of a proof of concept example and as a method of outlining the solution environment. Multiple qualitative data collection methods were engaged to facilitate knowledge acquisition in the domain of milk protein enhancement for dairy operations. This paper also describes the generic development procedure used in this project.

Keywords: target-specific expert systems; design environment; rural application

1. Introduction

This article describes development of a new solution architecture in which industry operators can build their own target-specific expert systems (TSES) using their own knowledge. The development methodology ensures end users such as farmers/rural business operator's involvement in the development process and afterwards encourages the use of contextual knowledge for building their specific expert system in the design environment. We have called this system an end-user enabled design environment (EUEDE). EUEDE represents a specific type of design environment where end users involvement is central. Other reason behind calling the system EUEDE is that our aim is to focus on the end user's thought processes, relevant technology and their own judgement in order to give them active participation in their own application development. It is hypothesised that this will contribute to increased ownership of the developed application, and help to increase the adoption rate of the developed application. This new methodology takes traditional ES development technology one step further by ensuring active end user involvement in development and by reducing third party involvement. It is also thought that by reducing end-user's training requirements with respect to analysis and design (Wagner, 2000) and by reducing risk associated (McGill, 2002) with end users development that a better quality product will be produced. McGill (2002) suggested that end user development (in particular spreadsheet applications) does come with some risk and this risk can be in terms of using incorrect design variables and inappropriate design methodology. However, in the proposed design framework used here the end user can exercise their own choices in the context of their own knowledge use and their own operational knowledge with re-use and sharing provisions with respect to building their own TSES.

Previous literature in user-developed application (UDA) suggested that, it is appropriate to design a solution environment which could be useful for integrating design elements and processes instead of developing a single solution for the problem in a specific domain (Gammack, 2002). Consequently, many works have been initiated to empower end user solution development. For instance, Clarke (1997) designed a user-enabled framework using a Lotus Note based system which accommodated different inputs from users and knowledge from multiple sources for rapid information processing towards a solution. The type of user-enabled system Clarke (1997) discusses allows for iterations of process rather than enabling changes in the process of solution making in the application. In addition, this Lotus Note based system does not have many user provisions which could allow for the construction of the whole solution application. A few design environments for building decision support tools have been outlined over the past few years. For instance, Pop and Neugru (2003) proposed a development environment for constructing expert system that helped design professionals in the process of improving old implementation using latest technical features; Kim et al. (2000) outlined a programming environment for developing DSS in Prolog, that offered a set of dialogues to build and manage various components of DSS and top-level control components in the Prolog programming environment. In addition, Prebil and Kaiba (2002) described an object-oriented programming environment for originating proprietary expert systems in which designers can take care of input data, technical regulations relevant to customers and other parameters during the design process. However, these types of solution environments are more suitable for technical designers rather than end users who want to develop their own solution through the selection of relevant variables and using their own judgement.

Incorporating different AI techniques is widely recognized as a way of empowering users with respect to developing systems in many previous studies of rural application development. Some examples of AI techniques include: ES development using rule based methods by Mahaman et al. (2003) and Plant and Vayssieres (2000); ES development using Knowledge based methods by Cohen and Shoshany (2002) and Girard and Hubert (1999); and ES development using neural network based method by Fu (1998). However, giving end users such empowerment in DSS development is limited. Though, not a novel concept in other domains such as banking applications, an earlier design environment called IDIOMS (Gammack et al. 1992) filled the gap by empowering end users in the development of DSS. The IDIOMS system uses a constraint-based knowledge representation in which decision making rules are derived from databases rather than qualitatively from human experts. The end users could then form a DSS model using the rules derived from the database. In particular, IDIOMS has resolved several limitations associated with traditional ES development. These limitations include a lack of context sensitivity, obligation of intermediary to engineer the system and systems build-in obsolescence. Our work advances the IDIOMS concept by utilizing the method of problem ontology for specifying decision requirements of end users in such a way that domain experts can assist directly. A set of expert rules for decision making is determined from domain experts, which are then used to generate the target-relevant ES according to the end users decision making requirements. Although in our case, the expert rules are often heuristic. This system offered a core technique that gives end users the opportunity for the rules creation or modification in a generic way. Our approach differs from the traditional AI techniques approach as well as IDIOMS approach in that rules are developed from heuristics rather than from databases. Another object of this approach is to discover the feasibility of the proposed design environment in the rural business by focusing on giving as much empowerment as possible to end users in solution building for rural applications.

In the main, ES development for rural applications provides decision support solutions in three directions or tracks. One track is the advisory systems which focused on replacing human expertise to enable decision making. In this example we can include the studies of Gillard et al. (1997), Mansingh, et al. (2005), and Mahaman et al. (2003). Another track in ES development is the use of diagnostic support tools. These focuses on symptom/clue based knowledge stored in the system. Some example includes Kramers et al. (1998); Li et al. (2002); Potter et al. (2000); Tomson (2000) and Yialouris & Sideridis (1996). Another track in ES development is planning and management support tools. These focus on management support knowledge. Example of this approach include the studies by Ellison et al. (1998); Lokhorst & Lamaker (1996); Matthews et al. (2006); Mohan & Arumugam (1996) and Nuthall & Hurley (1996). Findings suggested that most ES development uses rules based methodology although they used different AI techniques varying from agent-based to case-based decision support approaches. However, rules based methodology is limited especially when frequent changes are required. We adopted the rule based method using case based reasoning where the decision making rules can be modified, reused and shared in different cases.

Girard and Hubert (1999) suggested that strategies that farmers can use to manage their farming operations require advisors to understand and apply improved ways of achieving the required objectives. This system supports this strategy but reduces need for on the spot advice from the advisor. Using this design environment, a domain expert extension professional can provide their expert suggestions with respect to configuration and the setting out of farm-relevant decision making parameters. They can also provide relevant instances, and expert rules of thumb to make the design environment ready/fit within a decision making case of a specific farming operation. Subsequently, the system could be delivered to end-users for further building of their target-relevant ES. In this instance, the system promotes use of domain expertise knowledge to estimate the required/expected level in production using practical ‘rules of thumb’ rather than use of traditional mathematical or simulation based approaches (i.e. study by Hart et al. 1998 and Kerr et al. 1999). The developed target-specific ES contributes to a new way of providing decision support solutions as the human expert provides solutions with different classes of problems. In specific farming operations, the system provides an assessment of the current situation by determining the scope for operational improvement. It also identifies changes in the potential for improvement and gives an estimate of the benefits associated with each improvement as well as providing expert opinions on the current status of the farming situation by exploring possible cost improvements.

The proposed approach focuses on specific ES development issues in rural applications. In particular, our solution aims to facilitate a new technology over the conventional ES development approach for rural business. The application addresses such issues as systems rigidity, end users subjectivity in the context of use, obsolescence, intermediary requirements and imbalances in problem solving approach between end users and designers. Our approach also offers solution to reduce the additional rural DSS design issues identified by Cox (1996) such as the need for an analytical phase in decision support tools development, resolution, validation and appropriateness in relation to intended purpose. Moreover, in order to avoid over-engineered solutions, the proposed approach offers customisable but simple and feasible solution guidance in ES development for rural application. It also has a generic capability to fit in other livestock business domains.

The rest of the paper is organised as follows. Section 2 presents a general description of the research problem. Section 3 describes research methodology and knowledge acquisition procedures. Section 4 presents the system architecture. Section 5 describes the development procedures for the proposed design environment. Section 6 presents the system operations. Finally, Section 7 contains a brief discussion and summary of the development work.

2. Description of the research problem

The Australian Dairy Industry was deregulated in the year 2000 and this has greatly affected dairy operational practices. As a result, dairy business operators have had to explore more effective way of decision making, for example farmers receive incentives from the milk factories for higher quality milk at different seasons of the year and this is a different system to that of the past where the price of product was guaranteed provided minimal standards were met and production was based on a constant year round supply. The post deregulation incentives depend on the content of milk protein and extra payments are made for content above the minimum standard. Before deregulation, the milk factories provided a guaranteed price for quota milk and as a result, dairy farmers had less difficulty in allocating resources for milk production. However, in the recent deregulated environment dairy farmers have had to adopt changed strategic and operational decision making approaches revolving around how to cut the cost of producing milk while increasing production and taking advantage of the incentives offered by factories. As a result, dairy farmers need to think about how to enhance the quality of milk, for example increasing the percentage of milk protein. Expert advice on whole farm management factors such as cow feeding plans, calving plans and cow management can help dairy farmers attain levels of milk protein that can assist in profit maximization.

3. Materials and methods

A case study approach was adopted for conducting the research. The object was to acquire an in depth understanding of the decision-making aspects of dairy stakeholders. Multiple qualitative techniques were used for knowledge acquisition and verification, these included techniques such as focus group meetings which were convened over a two to three hours time period. Using heterogeneous approaches, we organised meeting sessions that integrated personnel from different but relevant expertise areas. These areas included dairy practitioners, dairy breed specialist, dairy system specialist and farmers. We found the participants were enthusiastic about the subject matter and were willing to share their views and knowledge in order to develop this tool. A relatively less-structured approach (Morgan, 2002) used for conducting focus group session where the goal was to understand participants thinking and the aim was to explore ideas in new directions rather than getting the answers for specific points. This facilitated interactions between the experts in the meeting and discussions helped us to acquire a clear understanding without any conflicts in expert's opinions. For knowledge verification, we employed the convergent interviewing technique (Dick, 2002) in which informal interviewing was used to ask experts individually about their specific knowledge.

As an initial strategy, we surveyed current literature with the aim of characterising the key issues in dairy operations associated with the problem domain. Studying internal documentations and booklets enable us to find the appropriateness of selected milk protein enhancement techniques for our study. Using this initial knowledge, we convened three focus group meetings on cow nutrition and management each of two to three hours duration. In these sessions we covered the impact of milk protein on feed dry matter intake, metabolisable energy content, and other feed values, farm management including the impacts of selected feed items, feed processes, feed use and limits imposed. Other factors considered included heat stress and breed management; especially the impacts of heat stress and breed types on milk protein. The first focus group session incorporated skilled personnel such as dairy nutritionists, experienced dairy practitioners and dairy farmers. The second focus group session incorporated skills from personnel such as experienced dairy practitioners, dairy physiologists, and dairy farmers. The third focus group session incorporated skilled personnel such as a dairy breed specialist, experienced dairy practitioners and dairy farmers. To verify the extracted knowledge, we used convergent interviewing with domain experts. In this approach, an informal one-to-one meeting was conducted. The elicited expert knowledge allowed us to identify the required decision making parameters, their impacts and relationships with different instances that lead to the development of the general problem ontology.

At the same time that the knowledge acquisition process is operating, a prototype development of the solution implementation has begun for end user and expert's assessment. This process involves two phases. The first being a spreadsheet based development of an expert system for demonstrating the extracted knowledge and concepts to the domain experts. This spreadsheet based ES is used as a vehicle to demonstrate concepts as suggested by Karire (2000). Karire (2000) suggests that the spreadsheet is widely used modelling technique for DSS and ES development. The developed spreadsheet based ES forms the basis of the target-relevant ES which is expected to be produced from the design environment. The other involves the development of a generic template of a design environment from the proof of conceptual knowledge which is demonstrated in the spreadsheet based ES. Development of the design environment is scheduled for four different phases (details in development approach section).By this way, the validated knowledge is used for designing the generic environment as a final deliverable prototype to the dairy industry.

As our proposed solution environment incorporates bi-directional activities by the domain experts and end users, we used forward chaining and backward chaining strategies for defining the differentiated tasks in terms of data-driven (forward chaining method) and goal-driven strategies (backward chaining method). For instance, a forward chaining method was used as the domain experts entered the decision making parameters in our development platform. Mansingh et al. (2005) suggested that a forward chaining strategy with data-driven reasoning is simple straightforward when knowledge is required to be modelled. On the other hand, a goal-driven strategy was used as end-users utilised the developed knowledge-base in our development platform. In addition, end users can be expected to use their developed ES for more than one purpose and domain experts may have less control of it, therefore, a backward chaining method is suitable. End user could consider all possible decision making parameters for obtaining expert suggestions in the relevant problems they are facing. For this instance, use of the backward chaining method (goal-driven strategy) for end users is justified in that the system is given a specific solution or expert suggestions after determining the scope that is needed to be improved.

3.1 Knowledge acquisition

The knowledge acquisition in this study included a successful knowledge extraction and elicitation from multiple experts. Literature from Stair and Reynolds (2005) suggests that knowledge extraction from multiple experts is problematic when the experts disagreed, however we did not encounter any conflicts between experts during the knowledge acquisition process in this study. Our elicitation process resulted in six main components relating to the problem domain as shown below;

1. Dry Matter levels in feed
2. Feed values
3. Water management
4. Herd management
5. Heat stress management and
6. Breed management.

These are consistent with 14 factors (i.e. average body weight, days in milk, major breed, average milk protein percentage, milk per day/cow, ABV[1], water availability per day, frequency of feeding, feeding access to pasture, average day temperature, relative humidity, distance between the shade and feeding area, approximate shade length, and sprinklers) in three instances (animal instance, management instance, climate instance) that are dominant for milk protein enhancement in dairy operations (Milk Protein handbook - DPI, 2006). The production rules developed from the expert's opinions are classified into six main relationships (figures 1 and 2).

We identified six main aspects associated with milk protein enhancement each of which has different impacts on potential protein levels in milk. These aspects were considered relevant by all dairy stakeholders. For example, by providing sufficient dry matter in a cow's feed milk protein was improved by a maximum of 0.3%. Each of these six aspects had a limit to the maximum expected potential milk protein and are used as building-blocks for the problem ontology.

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[1] ABV-Australian Breed Value is a calculation that estimates a cow's breeding values or its worth for breeding future dairy cattle.

A significant issue experienced during the knowledge acquisition process was caused by communication difficulties with domain experts. Li et al. (2002) also pointed to a similar bottleneck from Liebowitz and Baek (1996), which was mainly cased by the inability of the expert to explain the knowledge and inability of knowledge engineer to obtain expertise. We experienced issues associated with the second cause. Li et al. (2002) suggested that issues using multiple data collection techniques could handle this bottleneck. However, we used three strategies to minimise this issue in our project. These were an earlier survey on current relevant literature, use of an intermedieraty during focus group sessions, and to demonstrate the developed prototype in the focus group sessions for review of the concepts.

In the second strategy, we recorded the meeting discussions and used a person who has expertise in the problem domain to assist the knowledge engineer to understand and categorise the recorded knowledge. Though knowledge extraction from multiple experts is problematic, particularly when experts disagree (Stair and Reynolds, 2005), during our knowledge acquisition process, the reasons behind the non-conflict between the experts were. (1) The nature of dairy operational knowledge is justified in the science and this is accepted by all relevant experts and (2) Experts have already realised that the proposed system will have generic capabilities and will be changeable through their own justifications, so the extracted rules can be recreated or modified by any domain expert.

4 System Architecture

EUEDE serves two levels of functional processes in that it allows end user DSS development by allowing domain experts to build relevant knowledge bases where the decision making parameters, instances and rules are developed for the design environment. This is an expert's pre-setting activities which are important for end users who is less experienced in dairy farming overall. It reduces risks associated with selecting wrong parameters and rules from observed relationships. Accordingly, the second process involves development activities that allow end users to build their own decision support tools for evaluating their specific farming situation and obtain expert suggestions for further improvement. In this instance, end users such as farmers have provision to use their own set of decision making parameters to build the target-specific decision support tools.

The EUEDE architecture consists of three key modules which ensure the generic integrity of the system. The elements are a knowledge base module, an expert system development module, and a problem ontology module. The following section describes each module in the design environment.

The knowledge base module serves as intermediate module between the other two modules. The main role of this module is to assist in knowledge maintenance and the storing of the elicited knowledge. It helps in the creation of new parameters and rules relevant to specific farming conditions for the end user. It also holds the decision making parameters (DMP) table that is calibrated/adjusted by the domain experts. The parameters in this table are relevant to the system with underlying rules that have impact on specific farming aspects. This module displays the DMP table that allows end users to choose their target-relevant DMP's for building their specific decision support tools. The problem ontology module allows domain experts to create a knowledge base (KB) for the specific decision making context on a farm. Chan (2005) argued that an ontology model can be used as the basis for building knowledge acquisition tools, which in turn gathers domain knowledge for constructing the KB. Functions incorporating four sub-modules are available to help domain experts outline the appropriate problem ontology for the specific domain. These functions are designed to add new parameters or to modify the DMP, defining rules in different relationships, add or modify expert suggestions and test the KB to verify expert outcomes from the system.

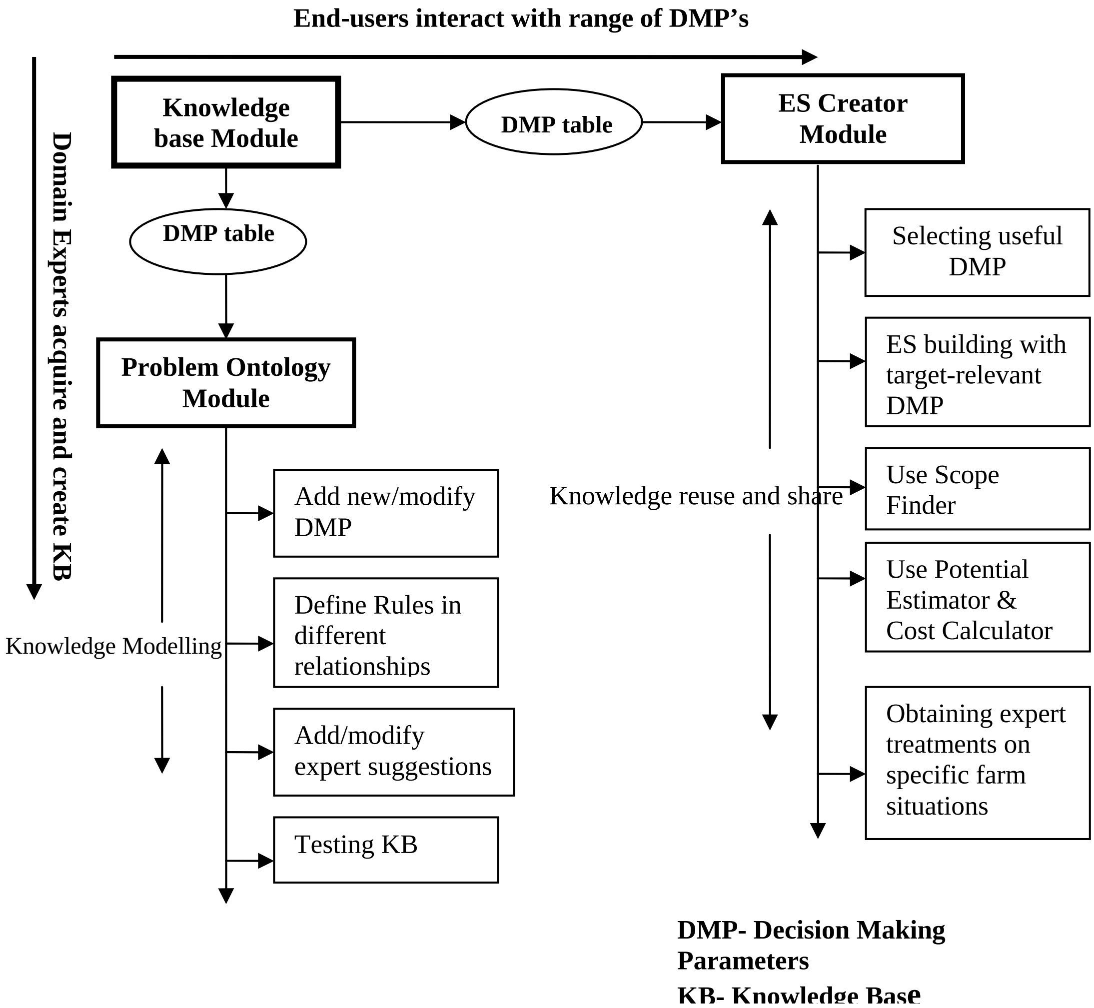

Figure 1: System architecture of EUEDE

Finally the ES development module generates the target-relevant ES automatically by corresponding with end users DMP selection. This module involves sequential activities such as DMP selection, ES building with the selected DMP's, scope finder, potential estimator and cost calculator and obtaining expert suggestion for specific improvements.

5. Development of EUEDE

There were three phases involved in the development process. In the first phase of development, a set of decision making parameters and the expert's 'rules of thumb' were estimated from the focus group meeting and verified by DPI's internal documentation and the Milk Protein handbook – DPI (2006). Subsequently, the project gathered the required expert knowledge to develop a sharing knowledge base for an ES in the domain of milk protein enhancement. The developed ES which was outlined from the extracted parameters and rules has been demonstrated in order to obtain end user verification. In the next phase of development, the parameters used in the ES gave us an opportunity to discover the generic components such as parameter definitions, the generic weight of parameters, the generic relationships/rules and the generic outcomes associated with decision making in the rural business domain. This first ES led to the development of the problem ontology.

The developed generic components or building blocks were then transformed into a design environment architecture in which the domain experts could calibrate the system to specific farming conditions. The developed design environment was then verified with the end users. This phase also involved a final demonstration to the industry. The complete development procedure is shown in the following figure (figure 2).

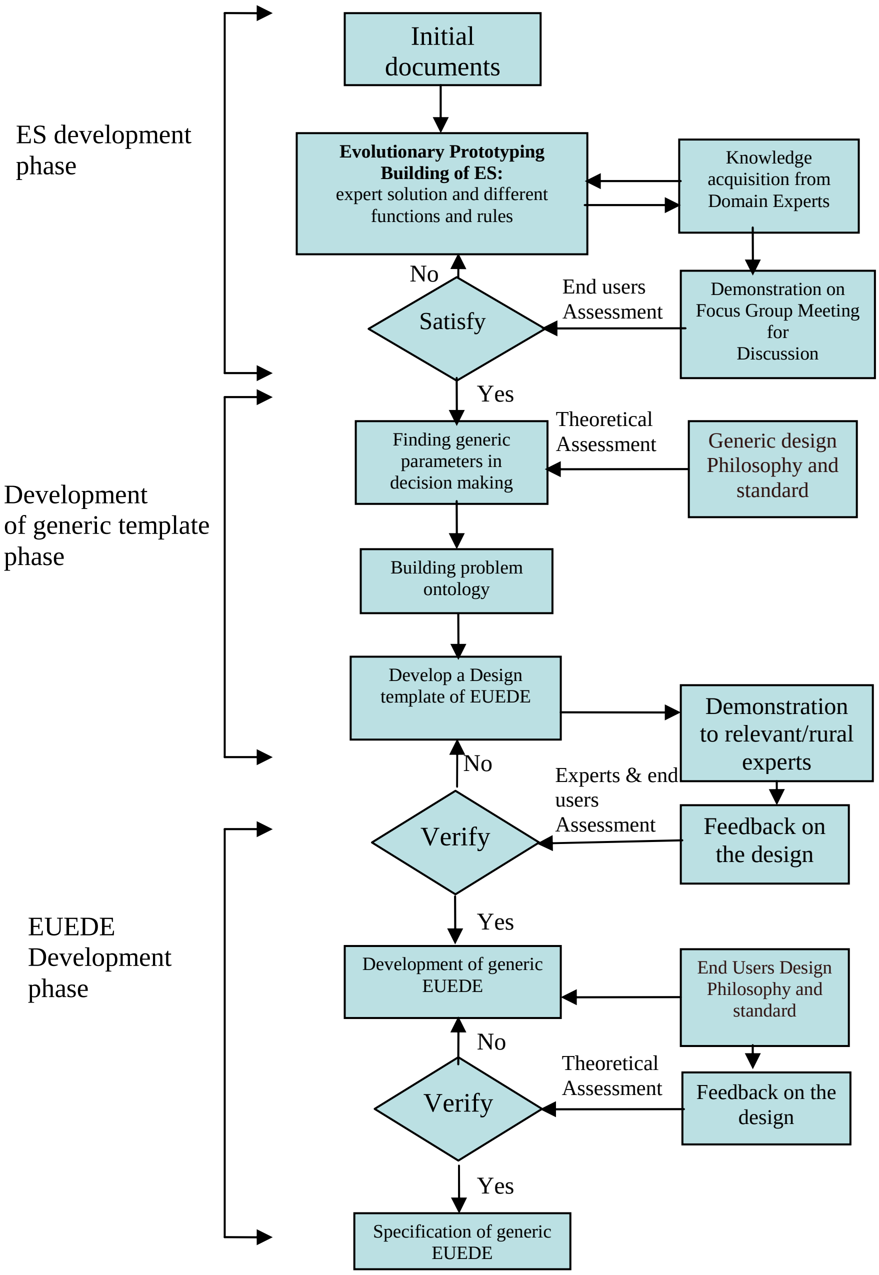

Figure 2: EUEDE development procedure through rapid development activities

Successful application development through evolutionary prototyping has been reported in rural business (Bloom & Chung, 2001; Kerr & Winklhofer, 2005; Quintero et al., 2005). These studies suggest that the key to successful prototyping development is the user's active participation in the development phases. We utilized this practice of end users participation for the development to ensure design acceptance rather than reporting user's requirements. However, studies by Bloom & Chung (2001) and Kerr & Winklhofer (2005) confirm that rapid prototyping seems to work well as it supports the key elements of the development processes such as integration, reusability and the finding of generic components which is the core knowledge in our study. In this project, the system requirements and project goals allow us to adopt the approach of evolutionary prototyping. Our development processes also rely on the traditional system development life cycle approach (Alter, 2001) because of the heavy emphasis on iterative process in every phase of development.

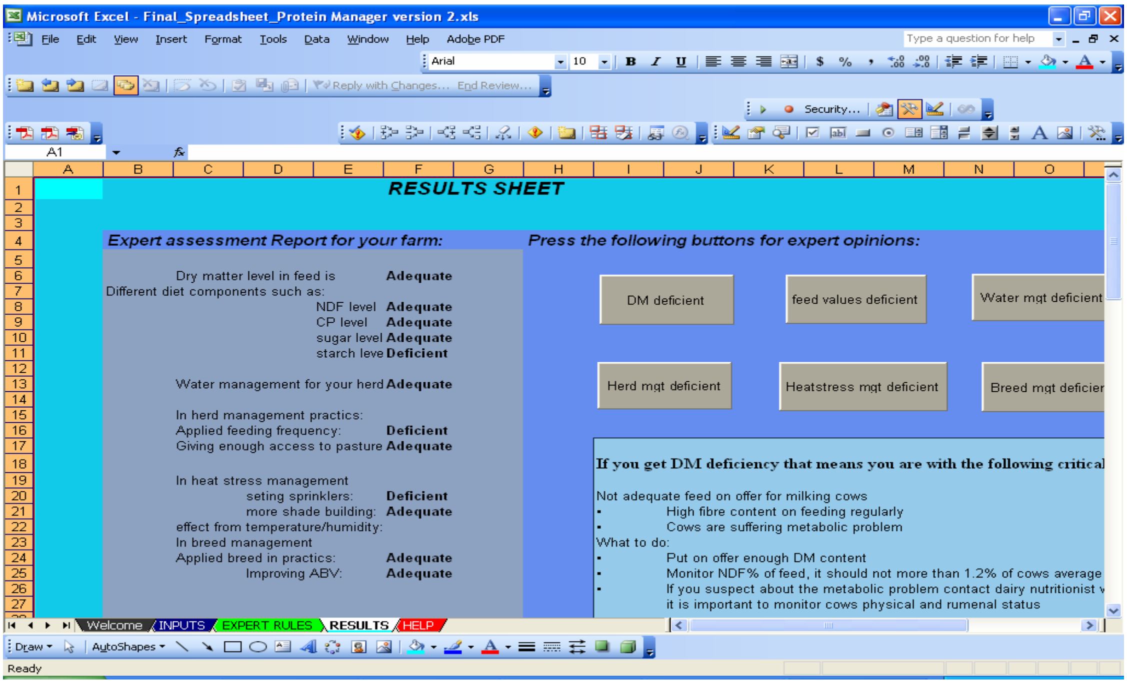

Figure 3: Expert results from the spreadsheet based ES.

The reason behind building the ES initially was to demonstrate the acquired knowledge in a meaningful way so that domain stakeholders can understand how the design environment template will work. In this ES, domain experts acquire the data and create the knowledge base on specific farming condition by adding decision making parameters, rules and expert's suggestions. Subsequently, the system is ready for end-users who can use those pre-settings to build their specific decision support tools selecting suitable decision making parameters, instances and production rules. Figure 3 shows expert results for farmers while applying preset specific farming conditions in our initial spreadsheet based ES.

5.1 Problem ontology construction

We engaged an approach for ontology construction called METHONTOLOGY for ontology development (Fernandez et *al*. 1997), which advocates the use of a structured informal representation to support the ontology development (Bally et *al*. 2004). Depending on particular problem task and development point of view, Chen (2005) distinguishes ontology into top level ontologies, domain ontologies, task ontologies and application ontologies. A top level ontology explains general concepts using class, event and process that are independent of the particular problem or domain. This type of ontology consists of common terms which are understood by a large number of users. Domain ontology describes the vocabulary that relates to a generic domain or specific task in the domain. The tasks could be monitoring, diagnosis and/or control. Task ontology is similar to domain ontology. Application ontology explains concepts which are dependent on a particular domain and task that are often a specialization of both the related ontologies. According to the above classification we adopted domain ontology development as our aim was to organise the domain knowledge so that it could be reused and shared. However, development of domain ontology is difficult because it requires detailed knowledge to map the relationships between the knowledge elements. We managed to acquire and configured the knowledge elements to outline a generic way of modelling the domain knowledge. We attempt to reuse this modelling concept for the other domains where similar characteristics of the knowledge will be experienced. Our argument in this paper is to provide this approach for all extensive livestock based rural business.

The set for developing domain ontology is associated with the problem ontology development for our solution environment where different independent knowledge elements were functional for configuration. This was used as the basis for the reusable generic EUEDE. The innovative aspect of the software solution is able to fit into other domains.

5.2 Generic feasibility of the system

The innovative aspect of the proposed EUEDE solution is that the architecture could be re-useable into other rural business domains such as beef cattle and sheep because, the decision making aspect in the production systems in these types of livestock-based rural business are very similar. For instance, the decision making rules

(rules of thumb) associated with water supply in the dairy business domain could be applied to the beef cattle industry by changing the required amount of water for beef cattle. However, in the other domain, our proposed solution architecture consists of four generic levels for domain experts. The first one is associated with the level for adding or removing parameters where the domain expert provides domain knowledge in terms of its building-blocks such as parameters, instances, classes and relationships. The second one is associated with the level for rules production, where the domain expert defines the decision making rules using ratios. The third one is associated with setting potential levels where the domain expert sets up potentials for target outcomes. The fourth one is associated with the ability to add/remove expert suggestions where the domain experts add suggestions for potential improvements.

The overall concept is to use this proposed system in such domains where some specific factors are important for potential businesses. The parameters that are obtained from external or internal sources have impacts on the business potential production levels. In most cases in the livestock based business, if we could tailor some factors with different business potential production levels and subsequently adjust the rules between the factors and the potentials using expert suggestions for improvement for each specific potential, then the system architecture could be useful for expert decision making by business operators. This makes the developed knowledge base in the EUEDE system a generic function in which the knowledge components are shareable and changeable.

6. System operation

The following figures are screen shots of the EUEDE design environment. For instance figure 4 illustrates the welcome window of the EUEDE where all users are required to agree with the terms and conditions for system use. Figure 5 illustrates the decision making parameters (DMP) table where domain experts update domain-relevant decision making parameters, their instances, identified potential classes and relationships between the parameters and classes. This DMP database is used as storage of knowledge components of domain knowledge entered by experts. This database is also frequently re-used to create production rules by the domain expert.

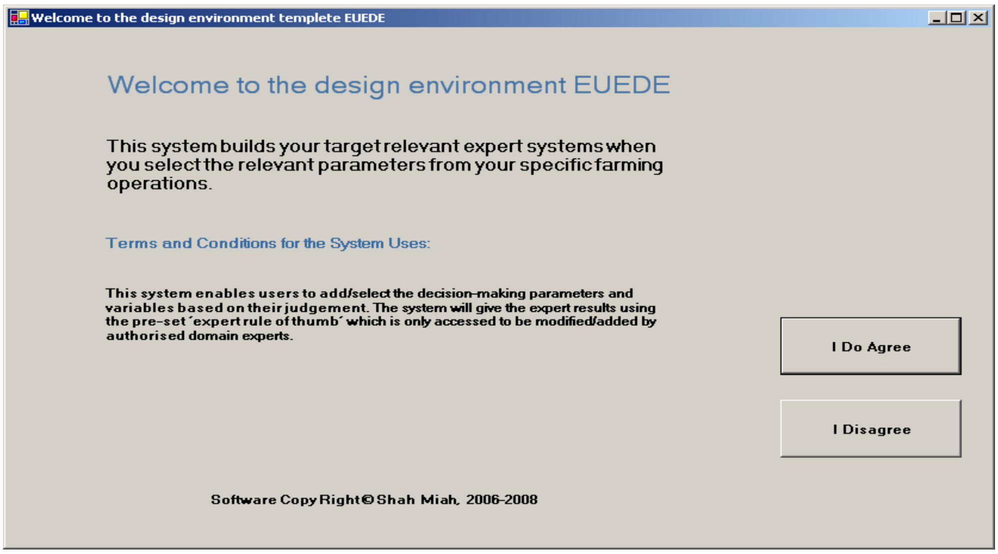

Figure 4: EUEDE version 2 template

Figure 6 illustrates the function for creating production rules by the domain experts. Experts select a potential class relevant to a parameter. Subsequently they define the ratio and associated mathematical operators. For example: if an expert creates rules for the required amount of DM for dairy cows, they could select DM level as a potential class from the class drop-down list. Then they can select body weight as a parameter from the parameters drop-down list, after they define a ratio (could be 3.2%) between the class and the parameter. Finally the expert will select mathematical operators for the defined rules. When the expert clicks on the save rules button (figure 6), produced rules will be stored and used as shown below:

Required DM = body weight * 3.2 %

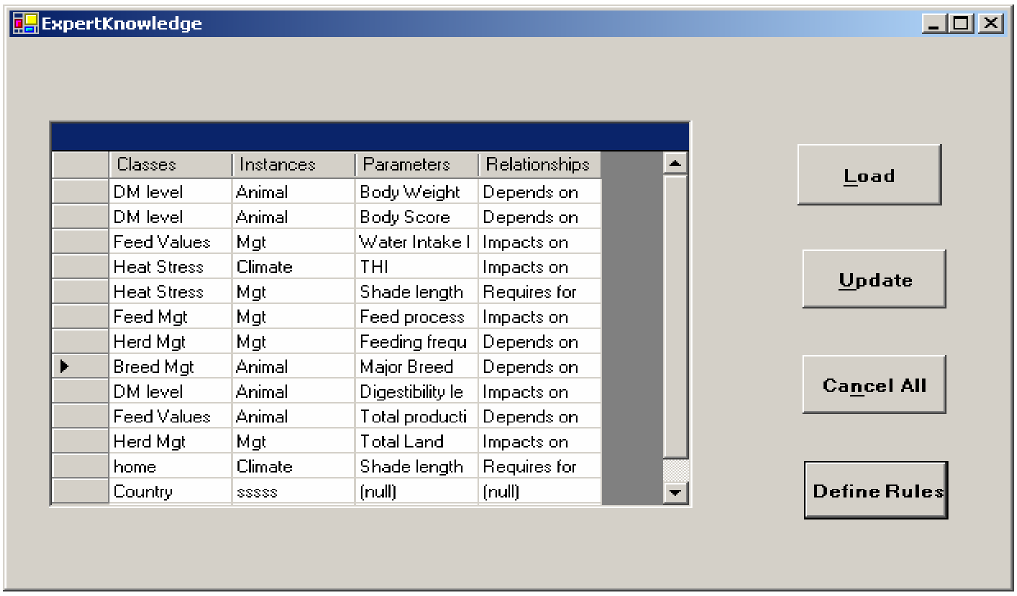

Figure 5: the DMP table displays the parameters and instances

In the developed ES, this required DM level (the above developed rule) will be compared with the current DM level to determine differences. This will indicate that there is either scope or no scope to improve the DM level. Consequently, when the end-user developed ES uses this parameter; it uses expert opinions with respect to DM level improvement. Currently EUEDE is under the process of continuos development.

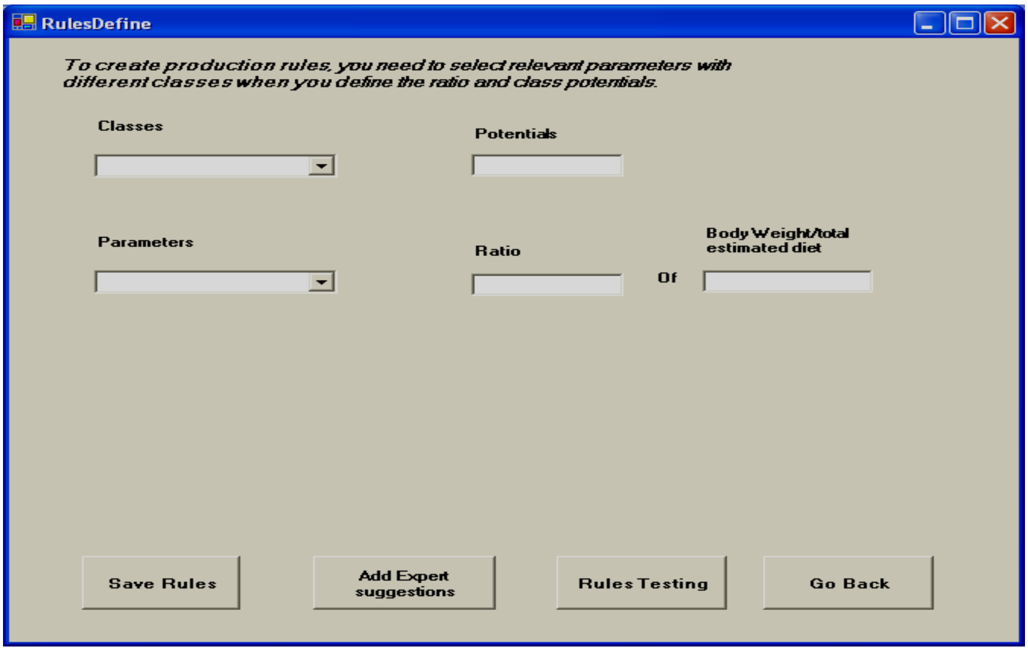

Figure 6: Windows where the production rules are being created in EUEDE

7. Discussion and conclusion

This paper described the development of a design environment where dairy professionals assist farmers to build their own TSES. Our proposed design architecture is different from the standard commercial ES shells (for example, EXSYS, ACQUIRE) which often encompass tools for the design, development, and testing of the knowledge base. In most of the cases, the traditional ES shells contain a specified format in which a generic interface engine and user interface is designed to integrate with a domain knowledge base. Knowledge engineers can use these shells to build ESs but they have limited options for the end user to tailor the system to their own requirements. In our case, the diversity of EUEDE not only offers options for the acquisition and structuring of the domain knowledge but also offers a way of tailoring the system to cater for rapidly-changing requirements demanded by end users.

The developed ES gives expert support to improve farming operations. One of the objectives of this paper is to document how the domain knowledge is used and modelled for the development of an ES for rural applications. On the other hand, using a generic problem ontology based solutions enables us to modify this model for use in other similar rural business operations, specifically extensive livestock based industries.
This approach aims to facilitate a new technology over the conventional DSS development tools used for rural business applications. This new approach also aims to overcome aspects such as systems rigidity, end users subjectivity in the context of use, obsolescence, intermediary requirements and differences in problem solving approaches between end users and designers.

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