A KNOWLEDGE-BASED SYSTEM TO TRAIN THE SOUTH AFRICAN RURAL FARMERS THROUGH A VSAT-ENABLED INTERNET SERVICE

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ABSTRACT

This paper describes an infrastructure to facilitate training the rural farmer and its impact on agricultural income. It describes a distributed communications architecture that connects VSAT-enabled rural telecentres to a central agricultural centre which disseminates information and provides training to farmers on agriculture. This paper recommends the integration of an intelligent tutoring software system for training rural farmers. Taking into consideration that rural areas might not be close to the National Electricity Grid, the project proposes solar energy as an alternative source of energy to power the remote telecentres. This paper looks at wool contamination as an example. Due to limited access to communication and information rural farmers are not well informed on the effects of high levels of contaminants on the price of that wool. When wool, is contaminated the auction prices are decreased.

Key Words: Wool contamination, VSAT, Internet, Knowledge-based, Intelligent tutoring, Expert system.

1. INTRODUCTION

Rural farmers are not always aware of how they could improve their income through the a doption of better farming methods. This is compounded by the fact that agricultural information which is supposed to reach some of these rural farmers does not get to them due to a shortage of staff or poor networks. To prevent the exclusion of these underdeveloped areas in national development, bridges must be constructed in communities using Information and Communication Technologies (ICTs). This study is aimed at overcoming the problem of lack of access to electricity and telephone services in the rural communities of South Africa required to bring the Internet-based training to these communities on wool contamination issues.

ICTs, such as wireless technologies, are offering new ways for communicating and exchanging information. Remote areas, which cannot be accessed by telephone, road or rail, can become part of the communications networks without the need for a highly-intensive on-the-ground infrastructure thanks to wireless technologies.

It is for this reason that this paper proposes an integrated communications system that effectively ensures that the farmers have access to appropriate information and training on agriculture. The proposed integrated system is based on an Internet system that uses VSAT technology for data transfer. Due to a shortage of staff to provide the training, the main agricultural centre is placed where resources and staff are available to produce content for training the farmers. Various solar-powered remote telecentres can then access these resources via the Internet.

The rest of the paper is structured as follows:

Section 2 introduces the technologies used. Section 3 gives an overview of wool contamination. Section 4 describes how proceeds from wool are calculated. Section 5 describes related work. Section 6 describes the architecture of an intelligent tutoring system. Section 7 reviews the pros and cons of this architecture and section 8 gives a conclusion to the paper.

2. TECHNOLOGIES TO BE USED

The work has a two-component solution. The project pursues a model of a wireless-based Internet access system to bring the Internet to remote areas and the design of an intelligent tutoring system for training farmers. The project looks at the idea of coming up with telecentres that are solar-powered to house these technologies.

The system has a centralised-decentralised architecture. Centralised in the sense that the main agricultural centre and resources are in one place, and the various telecentres can access these resources. The system is decentralised in the sense that the various telecentres each exist as autonomous units. Since most rural areas are remote and there is no telephone infrastructure in place on the ground in these communities, the alternative to Internet service provision is wireless technology. Wireless access providers may connect to the Internet using wireless or radio connections. The problem with radio links is that they only cover short distances, and hence cannot support remote areas.

The alternative solution to the radio mast is installing a Very Small Aperture Terminal (VSAT) with a gateway that drops to the telephone service provider. A VSAT is an earthbound station used in satellite communication of data, video and voice signals, excluding broadcast television. It consists of two parts; a transceiver that is placed outdoors in direct line of sight to a satellite and a device that is placed indoors to interface the transceiver with the end-user's communications device such as a Personal Computer (PC). The transceiver sends a signal to or receives a signal from a satellite transponder in the sky. The satellite sends and receives signals from a ground station computer that acts as a hub for the system. Each end-user is connected with the hub station via the satellite, forming a star topology. The hub controls the entire operation of the network. For one end-user to communicate with another, each transmission has to first go to the hub station that then retransmits it via the satellite to the other end users. VSAT can handle up to 56 KBps.

To meet the electricity requirements a cost-effective alternative source of energy, such as solar would come in handy. There are two ways of tapping solar energy. One is to activate the computer with an alternate current (AC). A circuit is designed that takes power directly from the sun and outputs to the computer as AC. The problem with this is that variations in the intensity of solar energy lead to variations in the current, and also that at night there is no solar energy. The other alternative is to take direct current (DC) from the solar system, store in a battery, convert it to AC using an inverter, and the AC then powers the computer.

An intelligent tutoring system is an expert system [7], [6], and [25]. Expert systems are interactive computer programs that incorporate expertise and provide advice on a wide range of tasks. They solve a specific complex problem using reasoning processes that resemble those of human experts when they solve the same problem. They mimic the decision-making and reasoning process of human experts by providing expert advice, answering questions and justifying their conclusions.

Figure 1 shows a schematic view of an expert system. The system typically consists of the following basic components: knowledge base, workspace user interface, explanation facility, knowledge acquisition and inference mechanism. The heart of any expert system is the knowledge base. The knowledge base is a collection of general facts, rules and models of the behaviour of the problem domain. Other forms of representations commonly used are logic, frame-based schemes, neural nets, and the object-oriented approach.

The workspace contains facts that reflect the current state of the problem. The workspace is used by the inference mechanism to guide the decision-making process.

The inference mechanism monitors the execution of the program by using the knowledge base to modify the workspace. It manipulates the workspace using the knowledge base. The system uses either forward-chaining or backward chaining to solve the problem. Backward chaining is an approach which starts with the goal, e.g., "By how much will the selling price of the wool be decreased if the amount of the vegetable matter in the wool increases by 10%". Forward chaining inference engine tries to prove a goal or rule conclusion by confirming the truth of all its premises. These premises may themselves be conclusions of other rules. It is a method that begins with a set of known facts or attributes and applies these to rules that use them in their premise.

The function of the user interface module is to accept the problem description from the user and interact with the rest of the system in order to analyse the problem or augment the capability of the system. It provides an interface between the user and the expert system, usually as a command language for directing execution. The interface is responsible for translating the input as specified by the user to the form used by the expert system and for handling interaction between the user and the expert system during the decision-making process.

The explanation module provides explanations of inferences used by the expert. The explanation can be on why a certain fact is requested or how a conclusion was reached. The knowledge acquisition module serves as an interface between the experts and the expert system. It provides a means for entering domain-specific knowledge into the knowledge base

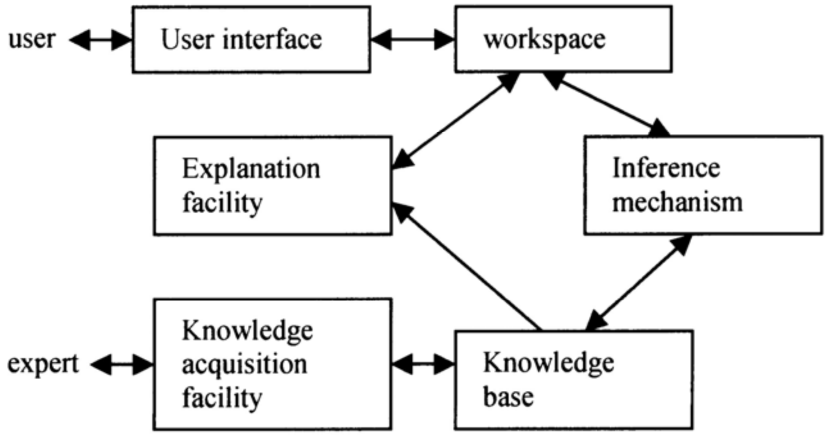

Figure 1. Schematic view of an expert system

and revising this knowledge when necessary.

3. CONTAMINATION OF WOOL

Impurities present in wool can be classified into three groups, natural, acquired and applied [11], [10]. The natural impurities consist of wool grease and suint or sweat from the sheep, and dark and medullated fibre contamination. Acquired impurities include minerals and vegetable matter. Applied impurities include branding fluids, sheep dipping material and other pasture dressings.

Dark and medullated fibre contamination: Not only visible dark areas such as black spots, but also isolated pigmented wool fibres which cannot be detected in the shearing shed, contaminate the wool. Some sheep develop age-related black wool spots in the fleece, due to exposure to sunlight

When dark or highly medullated fibres are identified in greasy wool the discounts applied can be substantial. When present as sporadic clumps or isolated fibres in the wool, bulk these faults can easily escape visual detection and cause problems in processing. The largest costs to the wool industry occur after blending of various growers' lots and value adding by processors when the fault of dark or modulated fibres is first detected. Dark fibres and highly medullated milky white fibres limit flexibility of end-use and when identified during late stage processing may require expensive fabric or garment mending. Dark fibres form a visible defect in white or pastel dyed products and highly medullated (objectionable) white fibres may not absorb sufficient dye, reflect light differently and stand out in coloured products.

In order to reduce the risk of pigmentation wool from crossbreds and comebacks, young sheep showing lamb tip (i.e. lambs, weaners, hoggets, etc) and sheep more than five and a half years old must be excluded.

Vegetable matter contamination. Increased vegetable matter and seed lowers the auction price of wool. Vegetable matter is picked up by the fleece of the animal. If these are not removed during carding and combing, they result in faults in the yarn and fabric. The cleanliness of the grassing area is of paramount importance. Pastures need to be clipped or sprayed if they are contaminated with vegetable matter. Feeding areas that are excessively muddy or sloppy with manure also lower the clean yield of the wool. It is only the amount of clean fibres that the customer wants, and these will determine the final price.

Preventing wool pack contamination of greasy wool. Research has shown that wool pack material contributes to the contamination of greasy wool during bale handling and caring. One of the biggest factors facing the sheep industry is contamination by jute and polypropylene. These will stand out in the fabric if they are not removed.

Urine stain. There are specific sites for urine stain on the sheep. On wethers it is concentrated mainly in the belly wool around the pizzle. On ewes it is concentrated in the crutch region. During shearing, the belly wool is removed first and with it the urine stained wool of a wether. In the case of a ewe the stained wool is removed in two stages. The left crutch is shorn in the early part of the shearing cycle and the right crutch near the end. There is no attempt to separate the stain until shearing is completed. Therefore, there is more danger of urine-stain contaminated fleece lines from ewes than those from wethers. It seems obvious that the best time to remove stain is during shearing process. Urine stain affects the colour of the wool.

Dogs. Dogs used as sheep herders, are likely to contaminate the wool. Avoid shearing with dogs within the vicinity.

4. CALCULATING THE PROCEEDS FROM WOOL

The actual clean price of wool is calculated using the Hedonic price model [18]. This model identifies price factors according to the premise that price is determined by both the internal characteristics of the goods and by external factors which affect it. The price of wool on a clean basis is determined by its diametre, length, level of contamination, in terms of vegetable matter, dark fibre content, wool coulour, etc.

Therefore the hedonic price methodology for wool is represented by the formula:

$$Pi = a + b\ Di + c\ Si + d\ Li + fVMi + gWCi + hPOBi \ldots\ldots + nSMi + ei \qquad (1)$$

where:

P is the actual price received in cents per kg clean for a particular sale lot denoted i

A is the intercept term

D is the average fibre diameter of the lot

S is the staple strength of the lot

L is the staple length of the lot

VM is the vegetable matter content of the lot

WC is wool colour

POB is wool position of break

SM is a dummy variable equal to 1 if the lot is staple measured and zero if it is not

Other factors, such as style, sale, date and sale location also come into the equation

e is the difference between the actual price received for the lot and the predicted price for the sale lot as determined by the model

b, c, d,…n are parameters to be estimated in such a way that the sum of the errors for all the sale lots samples are minimised; n is in effect the premium (+) or discount (-) paid for the staple measurements in cents/kg clean

The proceeds that a farmer would get for the wool they deliver to the auctions is calculated as follows [27]:

wool cheque = total wool produced (kg greasy) x weighted yield (%) x 0.93 (% MPG achieved) x 0.905 (after selling costs) x MPG for the point of micron (c/kg clean wool). (2)

where:

MPG is the micron price guide

% MPG achieved = net price (c/kg clean) / MPG for the micron (c/kg clean) (3)

The following is an example of the application of the above formulas:

Total wool produced = 50,000 kg greasy

Weighted average fibre diametre for clip = 22.7 microns = 69%

Weighted average yield for the whole clip = 93%

% MPG achieved = 9.5%

Selling cost = 427 c/kg clean

MPG for 22 microns = 385c/kg = (427-385)/10=4.2

MPG for 22 microns = 4.2 cents per micron

Therefore, MPG for 22.7 microns = 427 – (7 x 4.2) = 398 c/kg clean

The wool cheque = 50,000 x 0.69 x 0.93 x 0.905 x R3.98 = R115,566.96

A weighted average means that the fact that there are ore of wools of a certain type than others. For example, if there is 1950 kg of 22.5 micron fleece wool and 585 kg of pieces at 21.1 micron then the weighted average is calculated as follows:

Weighted average = ((22.5 x 1950) + (21.1 x 585)) / (1950 + 585)) = 22.18 microns.

5. RELATED WORK

The technology of modern intelligent tutoring systems is dominated by systems such as Blackboard [3] and WebCT [26]. Intelligent tutoring systems have been applied in stock investment advice [16], parameter passing in programming languages [20], English for deaf learners [13], teaching algebra [24], teaching formal languages [8], business-game simulations [22], teaching formal specifications in programming languages [15], and teaching law [2] as some of the examples.

Distributed intelligent tutoring systems have been addressed in various papers. [13] and [21] looked at a distributed environment for teaching artificial intelligence with agents. [19] looked at an Internet-based system for assessing object-oriented technology, [9] looked at web-based e-assessment systems, [1] looked at computer-based communications for cooperative work and group decision-making.

None of these systems addressed distributed intelligent tutoring systems in the textile sector.

6. AN ARCHITECTURE FOR AN INTELLIGENT TUTORING SYSTEM FOR WOOL CONTAMİNATION

The system is distributed geographically, that is, there are various telecentres around the wool-farming areas from which farmers can access information (see Figure 2). The telecentres in the various remote areas all access the main server in the main agricultural centre via a VSAT-enabled Internet to be able to utilise the intelligent tutoring system.

The system also allows connection to the Cape Wools database for information on auction prices via the Internet. The Cape Wools database provides the price range from the auction floor, that is, the micron price guide which the agricultural centre can communicate to the various telecentres. The user interface captures, from the user the levels of dark and medullated fibre contamination, vegetable matter contamination, wool pack contaminants, and urine stain contamination in addition to the parameters of average fibre diametre, staple length.

The knowledge base contains information on wool contamination issue and solutions to these. It also contains information on the various formulae to calculate the price of wool. The problem solver is the equivalent of the inference engine. The wool price is calculated on the basis of the parameters, such as the staple strength, staple length, and vegetable matter entered at the user interface and the information from the knowledge base on how to come up with the price. The knowledge acquisition tool assists in the capturing of the expert's knowledge on wool contamination.

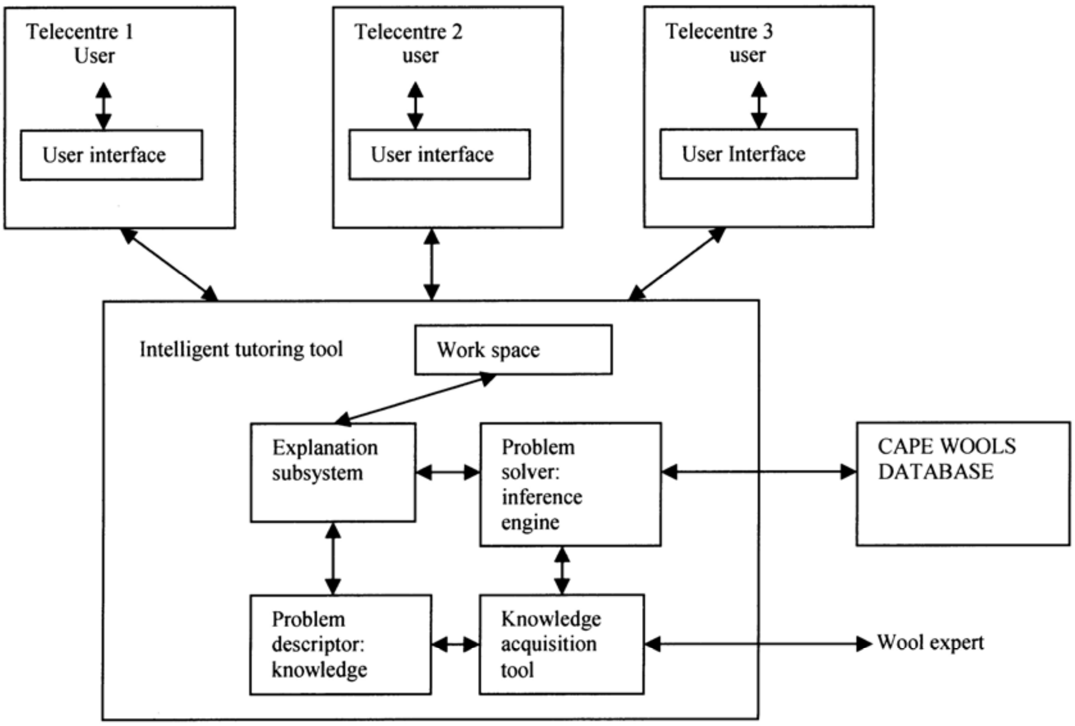

Figure 2. System architecture

7. THE PROS AND CONS OF THIS ARCHITECTURE

This system brings access to information to the doorstep of the rural farmer, which would otherwise have been hard to come by. That means the numbers that can access the training will be proportionate to the number of telecentres. The fact that all telecentres can access the same knowledge from the main agricultural centre means that expertise which is in short supply is not duplicated. There is no need for multiple sheep farming experts to train the distributed farming communities.

Through the automated wool income calculations, the farmers are able to immediately view the impact of various contaminants on what goes into their pockets. The system acquires information on the prices from auction floors automatically via the Internet without farmers being physically present on the auction floors

The system also has its downsides as follows:

- Lack of physical infrastructure, such as electricity and telecommunications in remote areas
- Initial high capital investment in hardware and software that is required.
- Skills and capacity needed to use, manage and maintain the technology are in short supply.
- Matching the most appropriate technologies with people's needs and capabilities
- The telecentre represents an alternative and competing information source to the local elders.
- Raising an awareness among the local communities on the benefits of such an undertaking
- Availability of expertise to maintain the equipment and provide training to the local communities in the telecentres is a potential threat to the sustainability of the project.
- Training of the illiterate rural folk from scratch in usage of ICT, especially for those who missed out on primary and secondary education is an area of concern as more effort has to be exerted. Only those with a sound educational background stand to benefit from the project if no rigorous training is undertaken.
- Ensuring the compatibility of the proposed system with the existing telecommunications infrastructure, as the system has to connect to the existing infrastructure
- The development of a secure and reliable system
- The financial aspects of such a venture, as automation is capital intensive

8. CONCLUSION

Without the knowledge, skills and communication capabilities required to access, analyse and share information, small-scale agricultural producers remain at the mercy of global market forces. With knowledge small producers can have a competitive footing on larger operations and corporate agriculture. Therefore, information can make a big difference to the contribution by small-scale farmers towards national development. This is what this research aims to achieve.

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