INTEGRATION OF ADVANCED TECHNOLOGY INTO A COTTON ANALYSIS AND DECISION SUPPORT SYSTEM

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Abstract

There is great need within the cotton/textile complex for an advanced software system designed for (1) online quality control of data produced by various cotton testing instruments, (2) rapid collection and immediate processing of it for integration into a distributive database, and (3) distributive resource (data and information) access for versatile analysis in a user-friendly graphical manner and instant visualization of results. The system reported here fulfills these needs. It is called the “Cotton Analysis and Database Interface System (CAnDIS).” CAnDIS is platform independent (i.e. it is independent of computer operating systems and thus compatible with Windows, Mac, Solaris, etc.) and database management systems independent (compatible with MS Access, Fox Pro, Oracle, etc.). It has a next-generation “graphical user interface” that makes data querying transparent to the user. These features are made possible by the integration of CAnDIS with advanced computer technologies; e.g., Internet, distributive database management tools, and new programming techniques and design tools. Through a specially designed network solution these features allows real-time access to and analysis of various data from diverse locations. The objective for CAnDIS is to facilitate decision-making processes, which starts with fiber characterization and (with system extension) can go all the way to textile manufacturing.

Online Quality Control of Data

For reliable characterization of cotton fiber, the very first and a very important step is to collect accurate data produced by various cotton testing instruments (CTIs). To this end, CAnDIS incorporates online quality control tools for testing of the new data validity.

On a regular basis, instrument calibration is checked by running tests on cotton samples of known characteristics (thus providing reference values), whenever possible. In other cases we check relative difference by using in-house reference cotton. The test results are evaluated both in terms of a mean value (m) and standard deviation (s) with respect to the reference values. The drift from the mean value is detected if the test value does not belong to the valid range of $m \pm s$, and the tester is warned of potentially erroneous data. CAnDIS provides visualization for comparison of the parameters in chart and histogram format. An example of Chart and Histogram for the Length of the Short Cotton Fiber is given in Figure 1.

The following is an example for an HVI instrument: The calibration procedure of the length/strength analyzer involves two calibration cottons of known characteristics. One is weak and short the other is long and strong. We have to run a check test few times a day to make sure that the instrument is giving accurate results. For that we have to run the two calibration cottons on the HVI and to compare the values obtained, in terms of both means and standard deviations, to the reference values. We all know that cotton is a natural agricultural product, so we have to set limits for its natural variability. If the values obtained exceed the fixed limits, we need first to check all the parameters having an impact on the HVI readings (relative humidity, temperature, optics of the instrument, etc.). If all these parameters look good a new calibration is needed.

The calibration itself involves also two calibration cottons of known values. The internal software of the HVI calculates regressions between the values obtained and the reference values. These calculations give us new slopes and offsets for length and strength.

CAnDIS adds two main features to this procedure:

1. Comparison of the new and previous slopes and offsets is done. Sudden and drastic change occurrence means that something had gone wrong with the instrument and we need to find the problem and to solve it. After solving the problem a new calibration will bring the slopes and offsets values back to their previous level. If only a slight change has occurred it could be simply due to the natural aging of the different components of the machine.
2. Comparison of the new and historical data slopes and offset is done to track any drift. This is the long-term quality control procedure. Detection of a drift means that something has gone wrong with the instrument and we need to find the problem (e.g. aging of some components) and to solve it (e.g. replacing the faulty components).

The other important quality control parameter will be (to be done as an extension) the on-line monitoring of the relative humidity and temperature. A warning system will be included to prevent technicians from running the instruments when the lab conditions are not within the fixed limits (65% of relative humidity +/- 2% and 70 degrees +/- 1 degree).

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The quality control information will be stored and attached to the final results send to the customer.

Distributive Database

Acceptable quality data from different CTIs at various locations can be stored in computer(s) associated with each CTI. A local telecommunication network along with Internet connects the relational databases (see Figure 2). Thus, for instance, a customer or a testing facility, located in Raleigh, NC can access electronic data warehoused in Lubbock, TX via Internet and vice-versa. Two or more local database systems are linked together to form a single distributed database system. Along with fast data processing, distributive database technology offers efficient ways of data collection, storage, access, and update. Data is collected and stored at the most commonly used location and yet is accessible to all locations involved.

Data Integration into a Distributive Database

Before we make use of the distributive database technology the raw data produced by CTIs must be structured and organized into relational (or tabular) data format. The standard data output from a CTI is a mixture of scatter plots, histograms, data points and text. To this extent, CAnDIS allows computerized data collection from HVI Spinlab 900 machine and transforms this data into relational database. Real-time creation of (1) new relational database or (2) addition to existing relational database occurs, as the raw valid data from HVI is processed. Raw data from up to 1000 tested bales at one time, with data collection of up to 200 parameters is possible. After understanding the requirements of cotton/textile centers we plan to create a "standard" relational database design for each CTI and for integrated collective database for all CTIs, to support the real-time data processing. The standard design will allow the application level optimization with respect to data modeling, data isolation, data retrieval, etc. Table 1 shows an example of a simple database unit. Currently, the data for CAnDIS is warehoused in the MS Access database on the local server and is accessible to all International Textile Centers' (ITC) Local Area Network (LAN) customers. However, LAN members do not need to be the only customers of this database.

Distributive Resource Access

CAnDIS's multi-threaded client-server architecture will make the standardized relational database accessible to all cotton/textile centers. The owner of the data can access the actual electronic data anytime, while rest of the community can access "coded" data that can be used for statistical analysis and research purposes without jeopardizing security for the owners. This will be possible by continuously running specialized application on the server warehousing the database.

The distributed resource accesses enables on-line data location, access, integration of information/data in to database, and easy usage of the data. CAnDISs' User Interface (UI) enables a user to examine a directory of available data and to formulate requests to extract the desired data as if a user was working with centralized data, making the "distibutiveness" of the system invisible to the user. The real-time performance allows users to produce instantly usable results, with most recently available data. Important issues such as concurrency transparency (several users accessing data at the same time), scalability of the system, security, error control and recovery, and language transparency (including UI semantics) are still to be implemented.

Statistical Analysis and Decision Support System

For real-time statistical analysis CAnDIS allows dynamic "rearchitecturing" of the database into foreground (FG, currently used local) and background (BG, rest of) database with intelligent communication between the FG and BG database. In addition, aggregate results, produced from past statistical analysis, are integrated into database and are also available for current use. In case of networking problems this feature allows the completion of current work, making the system more robust.

To facilitate the decision-making process of fiber quality determination, CAnDIS support number of tasks that a user can perform, such as

- ✓ Perform visual comparison of the parameter values. For example, obtain a bar graph of Total Trash for a number of cotton varieties. This feature lets the user obtain a better picture of the parameter distribution over the available spectrum of cotton varieties, observe any trends in the parameter values over a specific area or time period, see Figure 3.
- ✓ Analyze data from statistical point of view, i.e. obtain mean values, standard deviations, etc., combine information into histogram to review the distribution tendencies.
- ✓ Draft bale contents mix from the cotton varieties available to the user and modify the contents of individual varieties according to a sample desired parameter level. As one variety content is modified by the user, for example, increased, the rest of the variety contents in it are dynamically decreased to accommodate the induced changes. This is a sample application designed to demonstrate dynamic graphical capabilities and can be extended into on-line bale laydown calculation functionality, see Figure 4. It is, for example, possible to have a mix calculated so that cost is minimized while maintaining the required quality.

Operational alternatives choice is facilitated by including of visual relevance in control buttons, providing switching between tasks, see Figure 5.

Currently, the results are used to support the decision making process of validity of the raw test data from CTIs, as well as determination of the quality (and characterization) of cotton fiber. System will be extendable from the "decision support" point of view as database incorporates data for yarn production to textile production.

Graphical User Interface

The user interface is designed to meet the need for straightforward operations and aids users in formulating requests to access data and displays the results in a form useful to the user. CAnDIS supports multiple styles of user interface types. Information is presented to the user as graphical images that the user manipulates using a mouse or keyboard. As far as the database interaction is concerned, in general user interface consists of two building blocks the request constructor and the user interface translator.

Request Constructor provides an interface used by human users. A request constructor helps the user to formulate requests by accepting and examining the menu and parameters selections of currently valid options by the user and validating them for syntactical correction. CAnDIS Request Constructor is shown in Figure 6.

For instance a user needs to access records for cotton varieties Total Trash Content obtained in the Uster AFIS lab. Instead of formulating the query in SQL, the user selects the Database name and clicks the parameter (i.e. Total Trash) to access the records.

User Interface Translator is provided for each of the request constructor supported by the DBMS. The user interface translator converts the request in to a global transaction for processing by the other components of the distributed DBMS.

Currently, global transactions are performed using SQL, but the user is not aware of the syntax of each transaction, making it transparent to the user and easier to work with. In the example shown above the system constructs a query of the form "SELECT Total_Trash FROM Uster_AFIS", which is hidden from the user and is automatically submitted to the database, so user of the system does not have to worry about any knowledge of querying language, nor syntax errors.

The user interface of CAnDIS provides an effortless interaction to the database and facilitates the calculation process. It is a very important part of the whole DBMS, and in its turn contains the User Interface Translator and the Request Constructor.

Summary

In summary we have designed and implemented an intelligent rearchitacturable distributive database system for cotton quality analysis and decision support. Some of the major features of the prototype are:

- ✓ quality control 1: online quality control of data produced by various CTIs to validate incoming test data
- ✓ quality control 2: the different charts and statistics showing the evolution of the main calibration constants (slopes and offset mainly)
- ✓ status of the samples : graphical visualization of the results
- ✓ rapid data collection for HVI and immediate processing of it for integration into a distributive database
- ✓ statistical analysis for relational data from Uster AFIS, Stelometer, Shirley Analyzer, Spinlab 900 Series, Manufacturing Waste, HVI
- ✓ distributive resource (data and information) access: real-time access to and analysis of various data from diverse locations
- ✓ platform independent
- ✓ database management systems independent
- ✓ graphical user interface that makes data querying transparent to the user
- ✓ decision support for fiber characterization

The prototype functionality and technology used provides a solid platform for the following useful extensions that can be included in the system capabilities:

- ✓ quality control 3: future extension of on-line monitoring of environmental conditions for test labs (e.g. the relative humidity and temperature)
- ✓ status of the samples 2: results for the samples already done with few options to download the data (text format, excel format, etc...) from remote location, anticipated date of completion, etc
- ✓ future extension of online pricing: the customer will have the possibility to fill a form asking for example 100 HVI tests, 25 AFIS, 6 spinning tests, etc. and to get immediate pricing
- ✓ future extension possible for decision support all the way to textile manufacturing.

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Table 1. Example of a Database Unit.

Bale Number	Mike	Length	Uniformity	Strength	Elongation
28836	4.9	1.06	82.2	29.4	7.2
28837	4.8	1.04	83.2	29.7	7.3
28838	4.5	1.07	82.6	29.8	7.2
28839	4.8	1.8	83.6	29.3	7.1
28840	4.9	1.06	82.2	29.4	7.2
28841	4.8	1.04	83.2	29.7	7.3
28842	4.5	1.07	82.6	29.8	7.2
28843	4.8	1.8	83.6	29.3	7.1

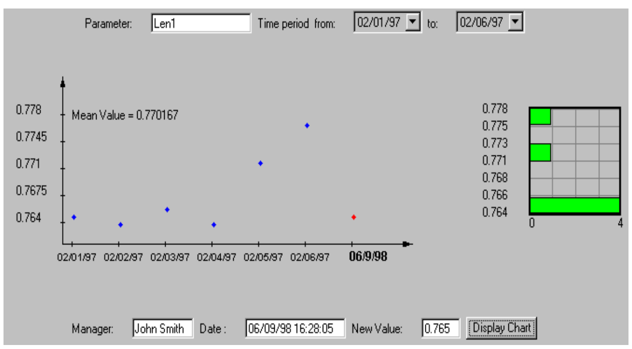

Figure 1. Example of a Chart and a Histogram

Foreground Database System

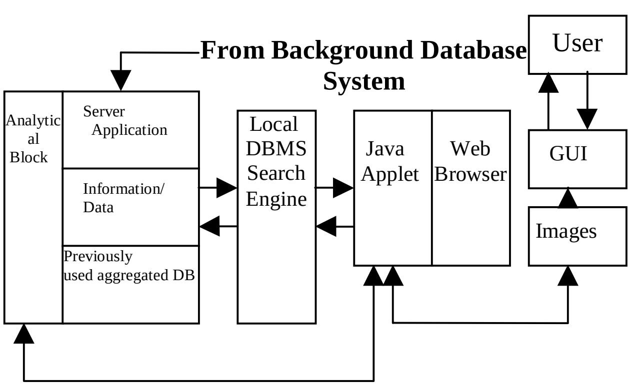

Figure 2a. CAnDIS Prototype Architecture.

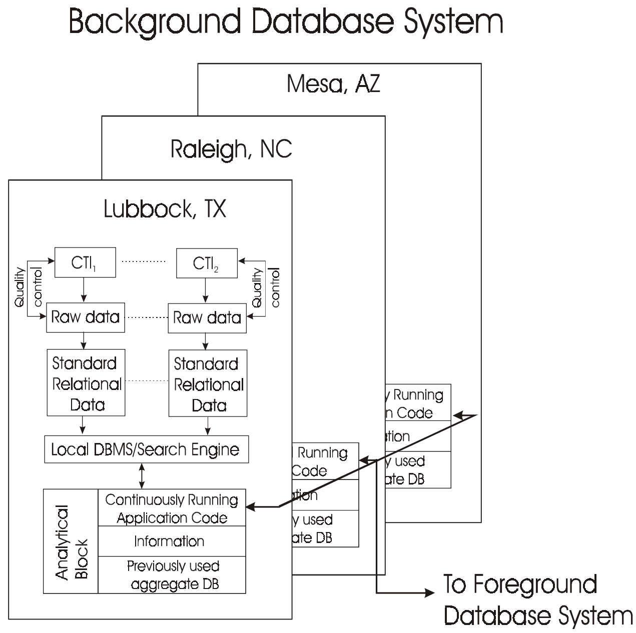

Figure 2b. CAnDIS Prototype Architecture.

Figure 3. Displaying query result information in the form of a bar graph.

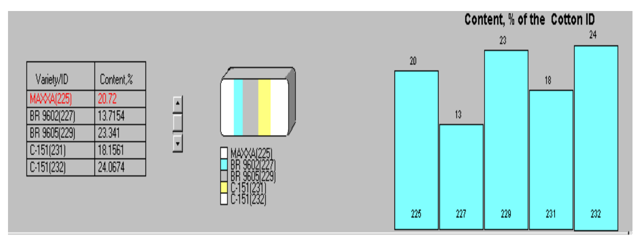

Figure 4. Dynamic Graphical Result Representation.

Figure 5. Control Buttons

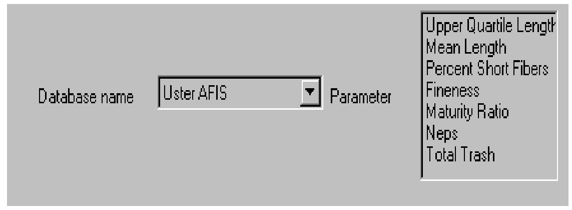

Figure 6. CAnDIS Request Constructor