The Establishment of 3D Database Management System and Its Perspective

Thu-Hua Liu, Tyan-Yu Wu, Wen-Ko Chiou, Yu-Cheng Lin

Department of Industrial Design, College of Management, Chang Gung University

259 Wen-Hua 1st Road, Kwei-Shan, Tao-Yuan 333, Taiwan

TEL: +886-3-3283016 ext.5420

Chi-Yuan Yu

Department of Industrial Engineering and Engineering Management, National Tsing Hua University,

Shinchu, Taiwan, 30043 R.O.C.

Tel: +886-3-5717654

ABSTRACT

The 3D optical whole body scanner research team has devoted to establish a 3D whole body anthropometric data bank and database management system for numerous possible industrial and research applications. The project uses a 3D whole body laser scanning system to collect digitized body shape. The scanned human body geometric data are then categorized and stored in the data bank for further sharing and data mining. This anthropometric data bank is different from others in the way that each scanned body shape attached not only demographic data but also links to its medical and health records through the cooperation with Chang Gung Memorial Hospital. This additional data linkage opens a wide opportunity for researches in many fields such as health promotion and health management. The results of this project so far are: (1) the establish of 3D body anthropometric data bank, (2) the design and implement of the anthropometric DBMS, (3) the web user interface of the DBMS. The ongoing researches are the On-Line Analytical Processing (OLAP) and the data mining systems. The OLAP system allows user to analyze the data by user's requirement, and the data mining system allows users to create the mining model to discover the relationship between geometric data and health data. Furthermore, a product designer can use the data mining system to automatically divide the customer into several different groups, and then design proper products to fit them.

Introduction

Due to the difference of race, age, gender, social class, and even the occupation, the human body shape and type diversify in many aspects. Anthropometry has been used to improve the design quality, usability, workstation and work place planning, and even laborer safety in ergonomic aspect for many years since World War II. Establishing a national anthropometry data base for our nation's citizen is now undoubtedly a necessity, while most of Western anthropometry data focus on the Western race.

Nowadays, the laser technology has broken through the traditional application of anthropometrical data. 3D digitized data can be collected in a few seconds easily through 3D scanner and accessed immediately from anywhere in the world, through internet. This technology has pushed the anthropometry technology towards a digitalized environment, where allows researchers to access and study the ergonomic data in a very convenient way. Through digitized data management, this new technology has a tendency to bridge many fields of professional disciplines such as medical studies, industrial human factor studies, CAD/CAM, Reverse Engineering, entertainment applications and E-commercial applications. In this study, the focus is the human model collection, data management and their applications. The Taiwanese are the main study group to collect the digitized body data in order to establish a national anthropometry data base. The aim of this paper will discuss data bank development and management and its related applications.

Background

Anthropometry is one of the corner stone for ergonomics and user-centered design. The technique of anthropometry can be divided into three levels, e.g., measuring tools and methods, data analysis and sizing / mapping, and related applications. The advanced and integrated technologies, such as optical measurement, electronic signal and digital data handling, as well as computer software and hardware, have pushed the traditional 2D anthropometric data measuring into a new trend for using 3D optical scanning system to collect anthropometry data.

Through the cooperation with Chang Gung Memorial Hospital (CGMH), the system is estimated to collect data from 20000 subjects within 5 years. This anthropometric data bank will be different from others in the way that each scanned body shape attached not only demographic data but also links to its medical and health records. This additional data linkage will open a wide opportunity for researches in many fields such as medical clinic, health promotion, and health management.

The 3D Whole Body Scanner installed in Health Center of CGMH has a better

chance to collect anthropometric data randomly from different areas of Taiwan. It is about 3000 subjects which have been collected within last year and applied to the study of obesity. The unique relationship between CGU and CGMH environment has led the research projects automatically connected to the studies of medical clinic diagnostics, health promotion, orthopedic application, and so on.

In the near future, the various projects for different applications will be integrated to this data bank with respect to the relationship of human body shape. At this point, in order to fulfill all requirements of applications, the data collection, file storage and management become important issues to be defined in their usability.

METHODS

The concept of data management is based on the knowledge-based approach to develop data bank which allow researchers, through website from all over the world, to access data bank and to manipulate data in individual purpose easily. In order to accomplish this goal, the accessing interface and website structure become a challenge in building a module in order to fulfill different requirements.

In this data bank, three different levels of data information are defined for the DBMS. These three levels are indicated as raw data, business, and presentation. The first level is raw data, which is stored as the data base format. The raw data table is directly linked to the digitized human model. Hence, all raw data can refer to a position on the human model. This raw data are available for the applications, through an additional programming process, such as statistical data bases. The second level is business application. It shows the information-based data base, which have been sorted upon sizing, mapping, mining etc., for individual application. The information-based result is presented as a table formats or digitized human model, which is depended on the needs of applicants. The information-based data bank allows users to activate on it or to do statistical analysis by customizing the software. The third level is the presentation. It shows the knowledge-based information in the website, which are the results of the research, member interaction and design applications. Those three levels of information are available for individual acquirement through Internet. For security concern, the authority of accessing level is reviewed and assigned by individual purpose. For instance, only doctors in CGMH are allowed to access both medical and health record and 3D data bank. Taking advantage of Internet and Intranet, the data linkage has open an wide opportunity for researches in many fields such as medical clinic, health promotion and management as well as product development and design disciplines in the future.

The structure of DBMS

The Data Base Management System (DBMS) is designed for bridging the gap between researches and applications which include medical studies, academic research, product development, and industrial applications. The idea of being broadly used in a variety of applications has led DBMS towards international vision while local applications have been processed in medical fields successfully. The basic concept of DBMS is based on the user's psychological needs, operational behavior, and knowledge-based contents, which are associated with interface design of Internet technology.

The construction of the core facility, which contains four building blocks, includes the following steps: (1) build and integrate the scanning facilities into a 3D body scanner, (2) establish a native (Taiwanese) 3D body anthropometric data bank, (3) design and implement an anthropometric DBMS, and (4) construct the DBMS's website for sharing the civilian Taiwanese surface anthropometry resource to support the human body geometric data related E-Commence activities. Another words, the structure of this system includes four sub-systems: 3D Whole Body Scanner System, 3D Human Model Process System, 3D Human Model Data Bank System, and Remote Site Access System. The following diagram shows the overall structure of this system. (Fig. 1)

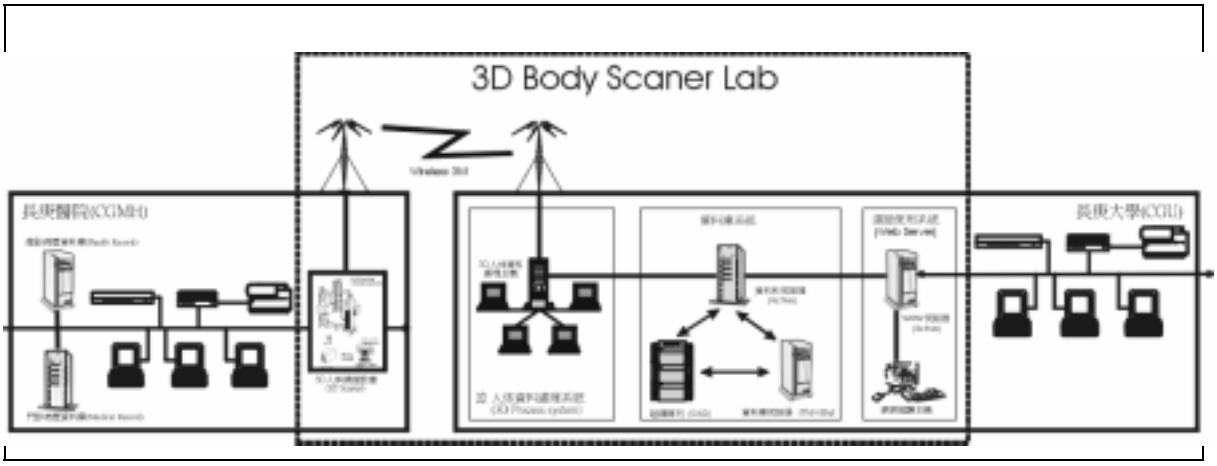

Fig. 1 Structure of DBMS

(a) 3D Whole Body Scanner System is built mainly for collecting 3D Human Model and raw data based information.

(b) 3D Human Model Process System is developed to process raw data, and process 3D Human Model, then, in order to fulfill data bank, which shows a different type of data information for different applications for future researches and studies.

(c) 3D Human Model Data Bank System is developed to store 3D human model and

data files. It involves the development of both hardware and software. This system in the future will be able to add more advance features such as establishing human surface modeling structure, human model analysis, and searching features of human model as required.

(d) Remote Site Access System is developed for serving remote site users through Internet technology. This system can offer far site users as much information as local site users can reach. These functions include the inquiry of texts, data, 3D human model, literature reviews, applications and other related information.

3D Whole Body Scanner System ----a Measuring tool

In this project, a laser-based 3D Whole Body Scanner is used as a measurement system, which is located in the Health Center of Chang Gung Memorial Hospital. The Hospital environment has provided a unique chance to collect a large quantity of Anthropometric data randomly and efficiently. The system has included four major parts: a stage with frame structure, 6 laser heads, a controller, a personal computer with an NT operation system and 3D data editing software. The detail specification is summarized in table 1.

Table 1. The Specification of 3D Body Scanner

Description	**Specification**	**Remarks**
Measurement Volume	(H)1900mmx(W)900mmx(D)500mm	
Exterior Dimension(booth)	(H)2950mmx(W)2300mmx(D)2170mm	
Total weight	About 900Kgs	
Laser Heads	6 pcs	
Precision	1 mm	
Stroke timing	15 sec	
Frequency	30 section/ sec	
Light source	Laser (meet ANSI class I)	Harmless to the body, eye safe
Operation System	PC/ WINDOWS NT	
Software	3D editer, Surface analysis, features measurement	Additional functions available
Output format	CAD interface available(IGES,DXF, STEP)	

3D Human Model Process System

TRID software with 3D whole body scanner is created to process the 3D digital data and 3D digitized human model. The product of data processing can be divided into four major steps: scanning human body, coding registration numbers, body

surface segmentation, and data filing.

The participants are required to stand still during the scanning processing. A digitized model with triangle-polygon image (tgl) will prompt on the screen right after finishing the scanning process. The operator will evaluate the quality of digitized human model to make sure the human model surface is in a good shape before moving to the further step. The coding number is simply to copy registration number of CGMH and the number will automatically extend to the file names of each digital model such as 1234567.tgl.

By recognizing this number, the health record of participants in Health Center of CGMH can automatically connected to the 3D human model for the future reference, diagnosis and applications. The medical case study has proved successfully that this system has a positive contribution in medical research. In the medical research project, the human model has been segmented into six parts, which are head, torso, left hand, right hand, left leg, and right leg. (See Fig. 1) The volume of each part has been defined precisely. By this way, the computing process will speed up because of partially processing data only, compared with the process of computing the whole human model. For example, the process of waist measurement for male has followed the indicating of umbilicus point on the human model, after doing segmentation of human model. The computer will compute only torso part of the human model and displayed the circumference of waist automatically on a table or human model. In this study, the basic measures of volume, surface, circumference of human model is computed by only indicating the measuring point. Waist hip ratio (WHR) is particularly calculated for the research requirement on health index. In this system, the data bank is not only can provide the each detail dimensions of body section, but also allow to calculate the depth of section, width of section, circumference of section and so on

Each segmentation will be assigned a file name compiled by registration number and identical suffix such as 0@1234567.sec.tgl, 0@1234567.tgl, 0@1234567.bmp, 0@1234567.pix, 0@1234567.wfm. The different file formats involves different applications. For example, the ".bmp", format is available for display the 3D image with light shading. The "wfm"formats is available to transform to ".iges" format in order to be compatible with other 3D application software like Alias for advance applications.

The edited function allows user to combine different information in documentation and make output for purpose. For example, by editing software, the Health Report of Health Center can attach 3D human body image in ".bmp" format along with some critical physical dimensions for the reference.

By simply indicates any position on human model, the table on the screen will

display the dimension of that particular measures. The attached fig.2 & fig. 3 are two tables shown statistical result of particular measures through TRID Software

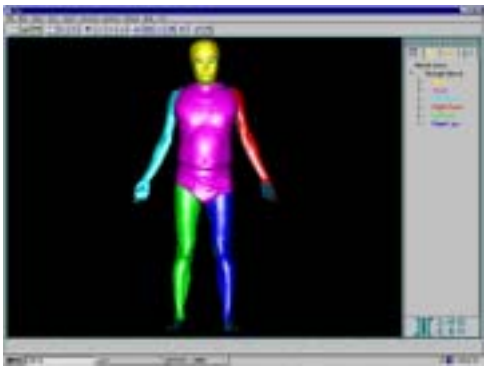

Fig. 1

In the future, the autumated landmarking technique will be developed in order to replace the process of manual placing position on 3D human model. This feature will rapidly reduce the labor work, especially, for processing a large quantity of human model data. The ideal positions for automated landmarking on human model will be located to the distinct turning point of 3D human model. For example, the top position of nipple will be the distinct point for measuring the circumference of the chest.

Fig. 2

Fig. 3

3D Human Model Data Bank System --- Data storage and management

The concept of establishing a data bank to fit into Asian Society, pacifically Taiwanese, is to collect 20000 subjects in five years by collaborative with CGMH.

This data bank contains not only demographic data, but also uniquely connects to healthy and medical record of a subject if these records are available. Therefore, it can provide a new channel for medical study and diagnosis reference in a very convenient way.

For confidential concern, in this case, only Doctors of CGMH can access both patient's health document and medical records. This feature has provided doctors another concrete information to evaluate patient's healthy performance. For security consideration, the safety gatekeeper system is established to review users to define accessing level. For the person, who take health examination in the Health Center of CGMH surely can have an output document with personal 3D human model image and critical body dimension for her/his reference in the future. This personal information will be connected to commercial applications, like the Internet shopping for personal garments, underwear and body related accessories.

Technically, this data bank required a very high performance computer to process all information, which includes the large quantity of raw data and 3D human model, text information and so on. In this system, there is four high performances PC under NT system which are used to serve different tasks: Website server, Com server MS SQL Server and File Server. Each server plays an individual function to the DBMS. A firewall surround the system is build to protect these four servers. The infrastructure of servers is shown in fig 4.

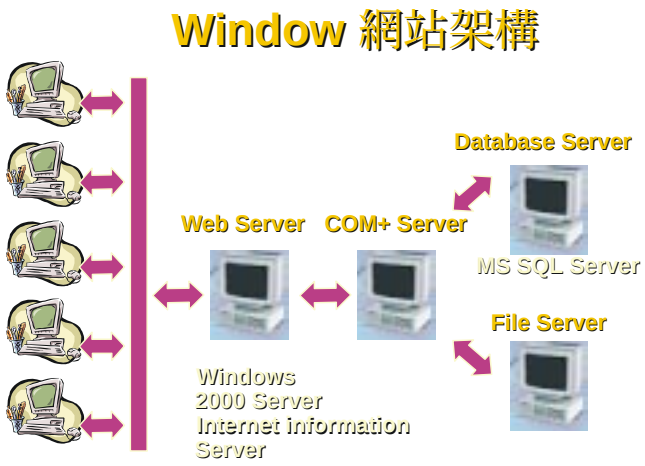

Fig. 4

Remote Site Access System ---- Data accessing and website

Remote Site Access System allows users access 3D human model and information of DBMS from remote sites without any boundary. This system tends to increase the interaction and information sharing in anthropometric study and applications. To become a membership of this website, all users can access this website by simply doing registration, through internet to the DBMS. This process

will activate the person to the member and allow accessing the information immediately. The password and user names are the basic information required to access the website. The DBMS system has provided mainly 3D anthropometric data, which includes 3000 data of Taiwanese currently, the anthropometric index, the schedule of ongoing scanning projects, educational training activities, and publishing articles, journals, and related papers, member list and suggestions.

The Application to Decision Support

Making better business decisions quickly is the key to succeeding in today's competitive marketplace. Business power comes not from data, but from knowledge that the people in an organization can use to make better decisions. One of the 3D body anthropometric data bank applications is decision support. Decision support systems extract knowledge from volume of raw data. In order to accomplish the task, decision support system is a tool to bridge the gap. The decision support system allows users to do prediction and the application of product design.

The relationships between human geometric data and health data were usually discovered by experienced doctors and researchers. They depend on the precedent experience to discover relationships and prove them by experiment and statistics. But the scene was based on the relationships had been suspected and then be discovered and proven. Doctors and researchers now can use the decision support systems to automatically discover relationships and do further research. Furthermore, when there is a new patient, we can predict he would have some health problem and suggest him to do further checkup.

Body anthropometric data play an important role on product design. Product designers refer body anthropometric data to design several size or style of product. Product designers now can use the data mining system to automatically divide the customer into several different groups, and then design proper products to fit them.

The under development decision support systems of the 3D body anthropometric data bank are: (1) the On-Line Analytical Processing (OLAP) system, (2) the data mining systems. The decision support systems are based on the data warehouse of 3D body anthropometric data and health data.

Data Warehouse

A data warehouse is often used as the basis for a decision support system. It is a database containing data that usually represents the business history of an

organization. This historical data is used for analysis that supports business decisions. A Data warehouse is an integrated store of information collected from other systems, and becomes the foundation for decision support and data analysis. It usually contain historical data, often collected from a variety of disparate sources. A data warehouse combines this data, cleanses it for accuracy and consistency, and organizes it for ease and efficiency of querying. A data warehouse is a database specifically structured for query and analysis. A data warehouse typically contains data representing the business history of an organization. Data is usually less detailed and longer-lived than data from an online transaction processing (OLTP) system.

Even though the term may mean different things in different organizations and environments, some characteristics are common to all data warehouses:

- Data is collected from other sources; for example, legacy systems or online transaction processing systems.
- Data is made consistent prior to storage in the data warehouse.
- Data is summarized. Data warehouses usually do not retain as much detail as transaction-oriented systems.
- Data is longer-lived. Transaction systems may retain data only until processing is complete, whereas data warehouses may retain data for years.
- Data is stored in a format that is convenient for querying and analysis.
- Data is usually considered read only.

OLAP

Whereas a data warehouse is the data store for analysis data, OLAP is the technology that enables client applications to efficiently access this data. OLAP is a technology that uses multidimensional data representations, called cubes, to provide rapid access to data warehouse data. It enables data warehouses to be used effectively for online analysis, providing rapid responses to iterative complex analytical queries. It organizes and summarizes large amounts of data so it can be evaluated quickly using online analysis and graphical tools.

OLAP provides many functions:

- An intuitive multidimensional data model makes it easy to select, navigate, and explore the data.
- An analytical query language provides power to explore complex business data relationships.
- Pre-calculation of frequently queried data enables very fast response time to ad hoc queries.

Data Mining

Data mining uses sophisticated algorithms to analyze data and creates models that represent information about the data, and helps an organization sift through large data sets to uncover hidden patterns and make valuable predictions about future business trends.

Data mining is an application-dependent issue and different application may require different mining techniques to cope with. In general, the kinds of knowledge which can be discovered in a database are categorized as follows:

- Mining Association rules
- Multi-level Data Generalization, Summarization, and Characterization
- Data Classification
- Data Clustering
- Pattern-based Similarity Search
- Mining Path Traversal Patterns

We use the data classification and clustering that provided by Microsoft SQL Server to implement the data mining system. It can be used to predict characteristics of new data and to identify groups of data entities that have similar characteristics.

Implementation

Figure 5 shows the architecture of the 3D body anthropometric and medical & health data warehouse.

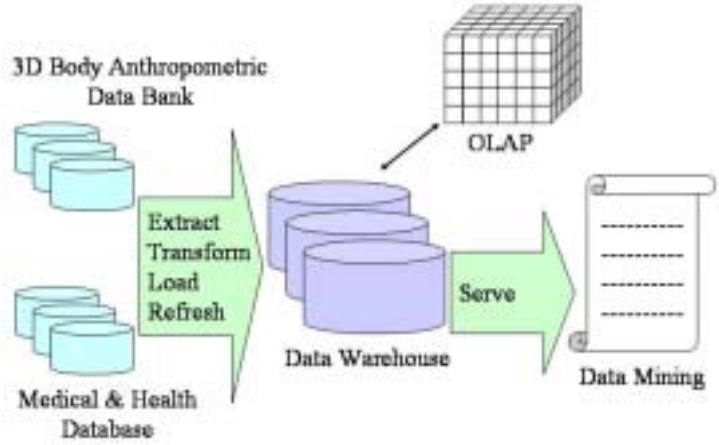

Fig. 5. The 3D body anthropometric and medical & health data warehouse architecture

The 3D body anthropometric and medical & health data warehouse is maintained separately from the 3D body anthropometric data bank and medical & health database. It includes tools for extracting data from the 3D body anthropometric data bank and medical & health database; for cleaning, transforming and integrating this data; for loading data into the data warehouse; and for periodically refreshing the warehouse to reflect updates at the sources and to purge data from the warehouse. The OLAP system analyze and visualization the data in the data warehouse. The data mining system (1) discover the relationship between human geometric data and health data; (2) automatically divide the potential customer into several different groups.

Figure 6 shows the software architecture of OLAP and data mining system.

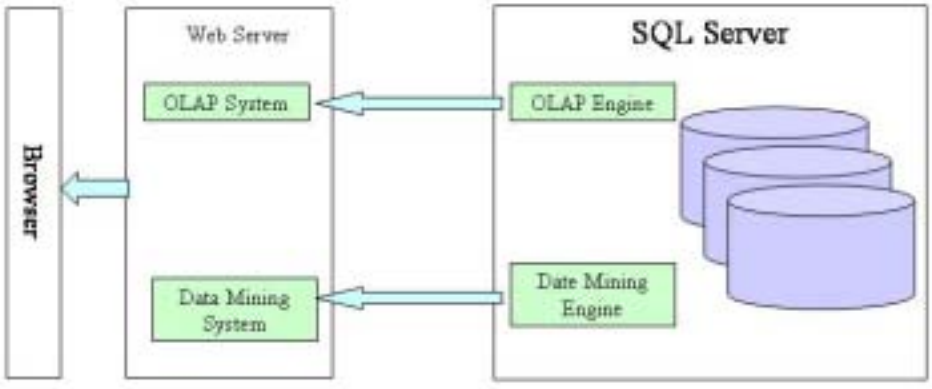

Fig. 6. The OLAP and data mining system architecture

The *OLAP* system analyze and visualization the data in the 3D body anthropometric and medical & health data warehouse and support rollup (increasing the level of aggregation) and drill-down (decreasing the level of aggregation or increasing detail) alone one or more dimension hierarchies (e.g. a day-month-quarter-year hierarchy).

The *data mining* system uses the decision tree and clustering algorithm provided by Microsoft SQL Server Analysis Services:

The *decision tree* algorithm classifies the data in the data warehouse and builds a decision tree. According to the decision tree, when there is a new patient, we can predict he would have some health problem and suggest him to do further checkup.

The *clustering* algorithm automatically divides the potential customer into several different groups (e.g. size L, M, and S) by input key attributes (e.g. face length and mouth width) of a product (e.g. mask) so that product designer can design proper product to fit customers in each group.

Data application and related projects

The final goal of this project tends to bridge the gap between research and application. The varieties of applications become the long-term result of this data bank. The connection between Chang Gung University and Chang Gung Memorial Hospital has provided the unique environment to do collaborative projects with respect to welfare design. The result of collaborative project, named Comparison of 3D anthropometric body surface scanning with Waist Hip Ratio(WHR), and Body Mass Index(BMI) in correlation of metabolic risk factors completed by Jen-Der Lin M.D., Wen-Ko Chiou Ph.D., Thu-Hua Liu Ph.D. etc. shows that 3D body scanning is valuable in predicting metabolic disorders including hyperglycemia, dyslipidemia, hyperuricemia, and hypertension. The Health Indices (HI= (body weight x2xwaist profile area)/ body height^2 x (breast profile area + hip profile area)) that determined from 3D scanning data is a better index of metabolic abnormalities than BMI or WHR.

Based on this data bank, there are five projects in the process that aim to tackle (1) feature analysis for human body and electrical human model, (2) the application of anthropometric database to the electronic commerce, (3) the application of anthropometric database to the design of disable aids, (4) application of 3-d anthropometric scanning in syndrome X, (5) the application of 3D anthropometric database to the healthy management system. For next future study, the projects include 1. The establishment of 3D whole body anthropometric data base for disabled people. 2. The individualized design and fabrication of total-contact seating system. 3. The design and fabrication of reflex inhibit pattern ankle foot orthosis. 4. The individualized design and fabrication of foot plate. 5. Individualized design and fabrication of lumbar support for disabilities.

These future studies involve a cross-section study of different fields, which basically based on this digitized human model as a tool to compute dimension and to transform the human model into design, CAD/CAM, Rapid Prototyping and Reverse

Engineering applications.

Conclusion

This paper draws a picture that the development of a national anthropometric databank for the nation's citizen is undoubtedly a necessity. The integration of Internet technology and DBMS can provided a better way towards the understanding of the anthropometric data in different races of the world. The most important is that it has become the bridge of research and application.

In this paper, it presents the whole structure of the data base management system (DBMS) and its applications now and then. It shows that DBMS has a great potential to develop to a worldwide website to share with other professions, through Internet technology. The collaborative projects with CGMH found that there is a new possibility of connecting medical research to 3D human model for the future reference.

In summary, this paper has concluded that the intention of this project is try to bridge the gap between academic researches and practical applications in the future. The contribution will be towards the improvement of people's living quality by providing more comfortable and ergonomic fitted products to the consumers.

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