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Development of an Artificial Intelligence Predictive Medical System for Analysis and Prediction of Fetal Parameters

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ABSTRACT

This thesis "Development of an artificial intelligence predictive medical system for analysis and prediction of fetal parameters" was motivated by the high rate of fetal loss in Nigeria which mostly occurs as a result of wrong medical predictive system. To solve this problem, software that will identify the fetal parameters that predicts the gestational age was developed. The new model will be a hybrid model. It will combine the Nägele's Rule and Mittendorf Rule to predict the foetal parameter. The new model will take the average of the two models as the predicted date of delivery. In this new system, it is noteworthy to name some ways of determining gestational age based on Last Menstrual Period (LMP). Therefore the proposed model will be a combination of the two model taking average of the number of days to be added to the LMP. This will be used to determine the Expected Date of Delivery in the new system designed. A platform for solving complication problems due to low and excessive birth weights at delivery by accurately estimating fetal parameters (Fetal Weight, Fetal Age, Conception Date, and Delivery Date) was implemented. This was implemented using externally generated data by combining the independent information about fetal size obtained from the three different approaches (i.e, clinical examination, quantitative assessment of maternal characteristics, ultrasonographic fetal biometry). Expert system methodology and Object Oriented Analysis and Design Methodology (OOADM) were adopted in the design of the predictive system.

KEYWORD: Fetal Parameters, Artificial Intelligence, Medical, System,

INTRODUCTION

To improve the healthcare system for expectant mothers, accurate determination of gestational age (GA) is essential for the provision of appropriate obstetric and neonatal care, including treatment of infections during pregnancy with drugs that may be contraindicated in the first trimester, detection of growth restriction and post term pregnancies (42 weeks gestation), provision of antenatal corticosteroids during preterm labour, and decisions regarding whether to administer or withhold intensive care to extremely premature infants (Rijken, 2012). Fetal crown-rump length (CRL) measured by ultrasound between $7^{+0}$and 13^{+6} weeks gestation is the recommended method for precise dating of spontaneously conceived pregnancies. Beyond 14 weeks, ultrasound up to 24 weeks is the upper recommended limited for accurate dating using other fetal biometry measurements including head circumference (HC) and bi-parietal diameter (BPD). However, in resource-limited settings GA assessment is prone to inaccuracy. Until recently the approach has been the effective use of computers and human resources. Today both cultural and procedural changes are needed to support the medical profession of the future, and these changes will require Expert Software Systems involving Object-relational database System and deductive Databases (rules and facts). In this thesis, the needs for the design, implementation, and application of a Computer Software which can mimic human thought, understand logic, and handle the range of problems, which are coextensive with the range of problems to which the human mind has been applied to the topic discussed, is examined, with the objective of solving the problems of complications primarily due to both low-birth weight and excessive fetal weight at delivery usually associated with an increased risk of newborn complications during labour.

Combining the different methods of fetal weight prediction to improve their overall accuracy may be possible. By combining the independent information about fetal size obtained from the three different approaches (i.e, clinical examination, quantitative assessment of maternal characteristics, ultrasonographic fetal biometry), the predictive value of fetal weight estimations can be improved dramatically. Therefore, this thesis provides computerized clinical expert system and provides solutions to these problems accompanying accuracy, effectiveness and efficiency in fetal parameters estimation.

METHODOLOGY

Methodology is the study of how to perform scientific research. It is the part of any analysis or research that is used to find out what type of

data is maintained, what fact to find and look for, how to find them and how to record them for usage. Many methodologies include a diagramming notation for documenting the results of the procedure; approach for carrying out the procedure; and an objective (ideally quantified) set of criteria for determining whether the results of the procedure are of acceptable quality. There are basically many types of system methodology which includes,

1. Prototyping system methodology,
2. Expert system methodology,
3. OOADM - Object-Oriented Analysis and Design Methodology,
4. SSADM - Structured Systems Analysis and Design Methodology, etc.

Expert system methodology was adopted in the design of the predictive system for comparative analysis of foetal parameters. Expert systems are interactive computer programs that mimic and automate the decision making and reasoning processes of human experts in solving a specific domain problem, through delivering expert advice, answering questions, and justifying their conclusions. The expert system is a rule-based expert system; it consists of three main phases as shown in Fig. 3.1.

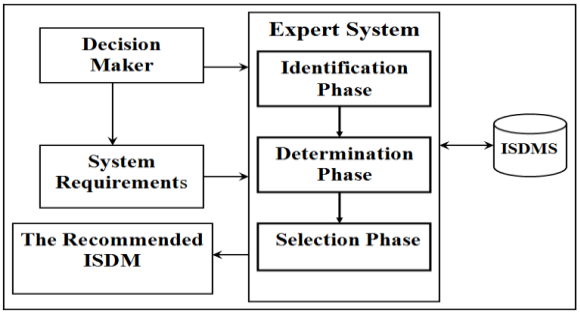

Fig 3.1: Expert System Framework

SYSTEM ANALYSIS

Analysis of the Existing System

In hospitals, medical record documentation requirements in the Prenatal and Postpartum Care measure to identify prenatal visits that occur during the first, second and third trimesters. Identify gestational age at birth from the hospital record (e.g., admission write-ups, histories and physicals, discharge summaries or labor and delivery records) or birth certificate. Gestational age is the number of completed weeks that have elapsed between the first day of the last normal menstrual period and the date of delivery. If gestational age is not available, assume a gestational age of 280 days (40 weeks).

Methods recommended to determine gestational age are as follows.

1. Physician ascertainment using ultrasound.
2. Last menstrual period (LMP) calculation (date of LMP – date of delivery) ÷ 7. If gestational age is recorded or calculated in fractions of a week, round down to the lower whole number.

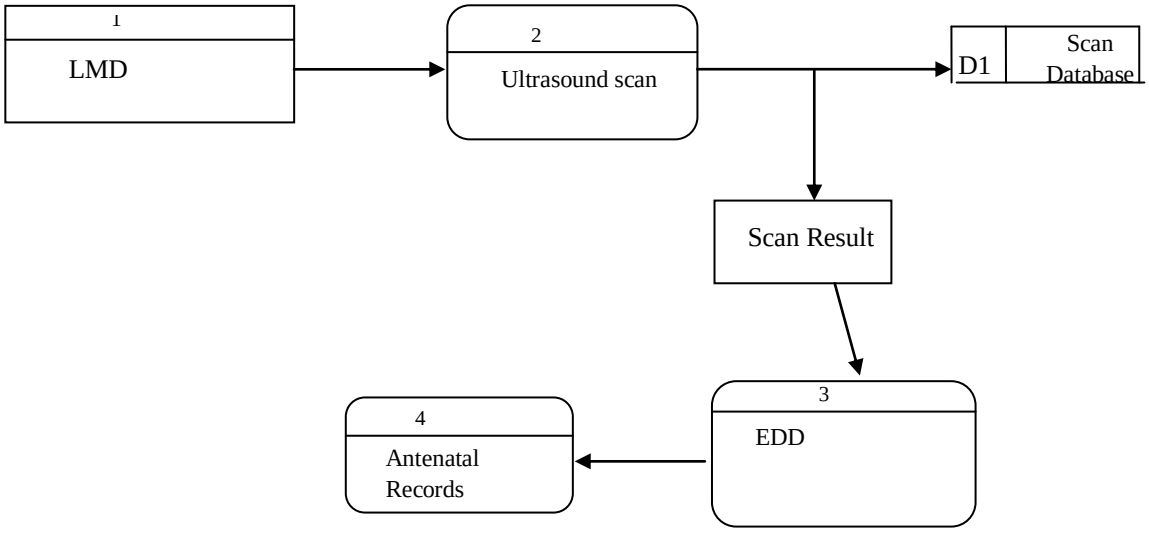

Fig 3.2: Data Flow Diagram of the existing system

Advantages of the Existing System

The existing system has assisted doctors and expectant mothers in the following ways:

1. Doctors were able to use the foetal parameters to predict the gestation age, delivery date and foetal age which is of great assistant to their clinical jobs.
2. The existing system has also helped expectant mothers to know when to expect their baby and get prepared.

Weaknesses of the Existing System

In using Last Menstrual Period (LMP) to calculate expected delivery date, "rule" doesn't take into account the fact that many women are uncertain of the date of their last menstrual period, not all women have 28 day cycles, and not all women ovulate on day 14 of their cycle.

Also, the quality of ultrasound imaging depends on the technical capabilities of the ultrasound equipment as well as on the experience and expertise of the operator.

Furthermore, other variables such as gestational age and fetal position may also influence image clarity. This can introduce some errors in the calculation. Also this necessitated for a medical expert to be involved in using the foetal parameters generated by ultrasound biometry to compute gestational age which will now attract more cost in the running of the system. The absence of a medical expert can stall the prediction of the gestational age.

Analysis of the Proposed System

The development of an artificial intelligence predictive medical system for analysis and prediction of foetal parameters is design to be used by healthcare centers and maternity homes to monitor the foetal development.

The new model will be an expert system and a hybrid model. It will combine the **Nägele's Rule** and **Mittendorf Rule** to predict the foetal parameter. The new model will take the average of the two models as the predicted date of delivery. In this new system, it is noteworthy to name some ways of determining gestational age based on Last Menstrual Period (LMP).

Nägele's Rule: To calculate Expected Date of Delivery, one should add 7 days, and then subtract 3 months from LMP.

Expected Date of Delivery = ((LMP + 7 days) - 3 months)

Example: ((the LMP on 1st April + 7 days) - 3 months) = January 8

Mittendorf Rule: To calculate "Mittendorf's Rule", one should add 15 days for first time Caucasian women.

Expected Date of Delivery = ((LMP + 15 days) - 3 months)

Example: ((LMP on 1st April + 15 days) - 3 months) = January 16

Therefore the proposed model will be a combination of the two model taking average of the number of days to be added to the LMP. This will give us the following formula.

Expected Date of Delivery = ((LMP + ((15 days + 7days) / 2) - 3 months)

This will be used to determine the Expected Date of Delivery in the new system designed

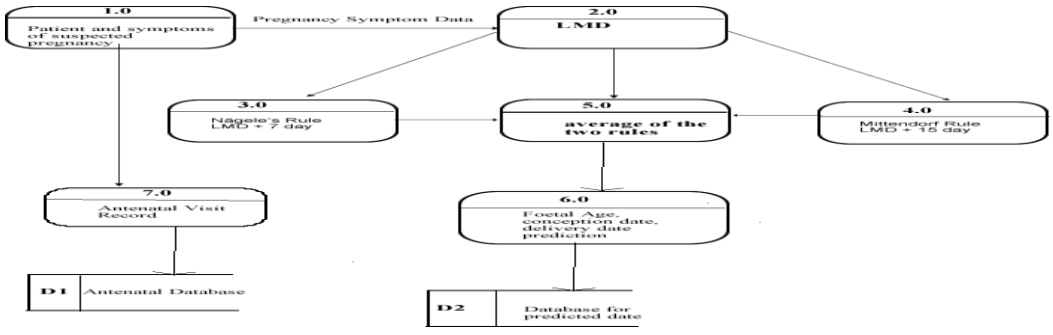

Fig 3.3: Data Flow Diagram of the proposed system

Also the proposed system was designed to keep track of antenatal visits of an expectant mother together with the related medical reports on the foetal development. The system modules includes: antenatal visits, Ultrasound Biometry, Foetal Parameters Prediction, foetal development analysis and other statistical reports which includes number of antenatal visits by an expectant mother before delivery, statistical report on delivery that occurred on the predicted Delivery dates, Gestational age and expected date of delivery reports, birth weight, etc.

Justification of the Proposed System

Reduction of still births and complications in delivery is a major aim of this thesis hence it justifies the need to implement the system to help expectant mothers have accurate predicted date of delivery in order to enhance safe delivery.

Some of the advantages of the new system include:

- The system will quickly and periodically estimate foetal age without mathematical stress on the doctors, clinicians or patients.
- The system predictions will be more accurate in terms of foetal age and other foetal parameters.
- The predictive system keeps track of foetal development and generates alert when the foetus is in danger. This will help to save lives of unborn babies
- Statistical analysis of foetal loss across the country will be easily accessible and can help government to analyze the regions that needs more healthcare facilities

System Flowchart

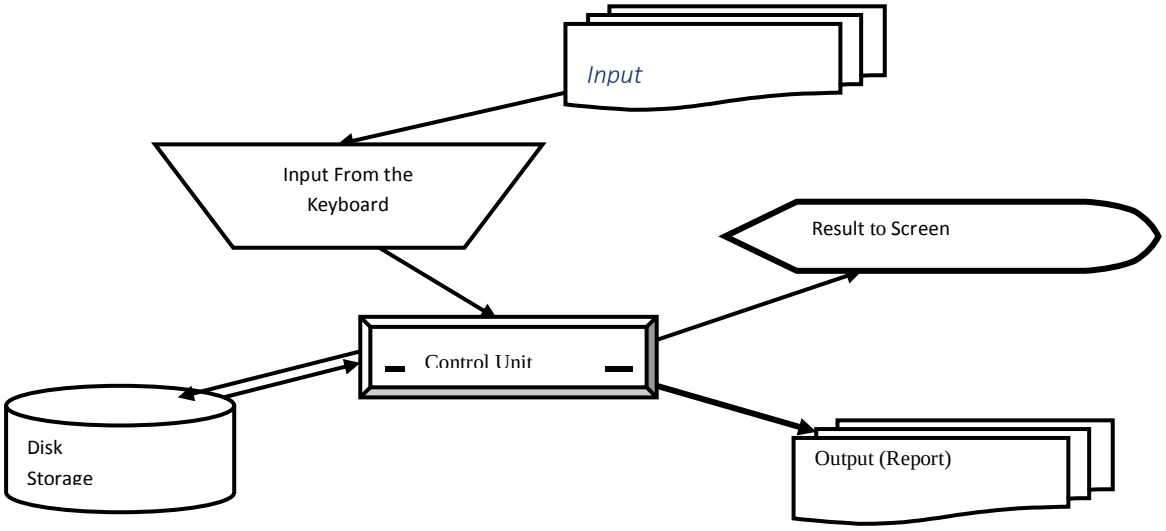

Fig. 4.16: System Flowchart

RESULT AND SYSTEM IMPLEMENTATION

Proposed System Requirements

The system requirement is divided into software and hardware requirement. Below is the detailed requirement for the proposed security mode.

Hardware Requirements

Table 4.7describes the hardware components and software requirements needed for effective and efficient running of the system

Table 4.7: Hardware Requirement

Hardware	**Minimum System requirement**
Processor	2.4 GHZ processor speed
Memory	4 GB RAM
Disk space	500 GB Hard Disk
Display	800 x 600 colors (1024 x 768 High color- 16 bit Recommended)
Internet	Wifi Internet Access

The table 4.6 above shows hardware components of the machine that allows the system to function as required for using the new system.

Software Requirements

Table 4.8: **Software Requirements**

Software	**Minimum System requirement**
Operating System	Windows 7 or later
Database Management System	MYSQL
Run-time Environment	Java Script, Wamp Server and Php
Picture Editing and Animation	Microsoft Fireworks

Program Development

The system was implemented using Php-Mysql programming language and Java Script. This is because the programming language has the advantage of easy development, flexibility and it has the ability of providing the developer with possible hints and it produces a graphical user interface.

Moreover, PHP-MySql is very user friendly and enables the design of an interface that can be modified programmatically. It consists of all necessary tools required to build main stream server Applications. The features of Php-Mysql and Java Scrip are as follows:-

i. GUI Interface
ii. Modularization
iii. Object Oriented
iv. Debugging
v. My-Sql Data access feature

System Testing

This section is chiefly the implementation of the application and testing for issues and non-functional properties such as speed and robustness. The test is simply the execution of the implemented application with sample data to ensure that all specified objectives have been met appropriately in order to ensure a high quality, user friendly application. The different tests to be carried out would be expatiated further in the subsequent sections. This approach aims at testing elementary units of an interactive system. Individual components that make up the system are tested to ensure that the system is completely free from errors System testing can be described as a series of tests administered on a complete system to ascertain the system's alignment with decided objectives.

We have three basic testing method that shall be adopted viz.

(i) Module Testing
(ii) Intergrated Testing and
(iii) System Testing

Database Testing

A database is a collection of logically related data. Also, these data are dynamic information required by the system. Each table in the database holds closely linked fields that are guided by a set of rules and constraints limiting the type of data stored in them. The Database Management System (DMBS) avoids abuse and misuse by ensuring that these checks aren't violated. The model database is made up of 7 tables and each table contains the name of the fields, data types, sizes and other constraints that define the table. Below are few screenshots of some of the tables along with a brief explanation.

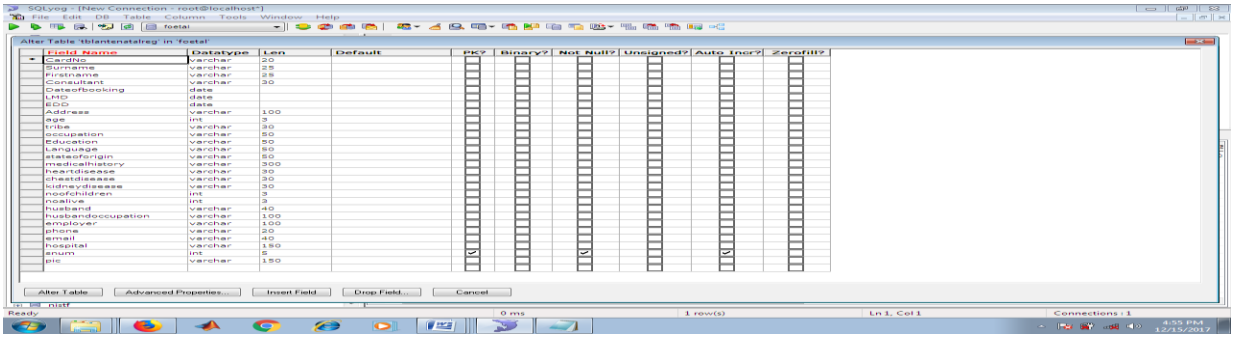

Fig. 4.17: Antenatal Registration table

Figure 4.17 shows the antenatal registration database table and this contains the pregnant mothers registration details.

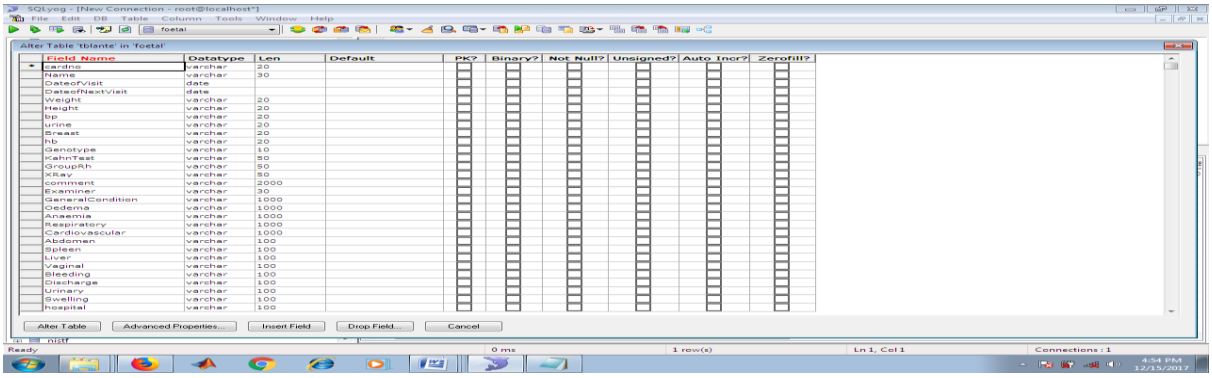

Fig. 4.18: Antenatal visit record Database

Figure 4.18 shows the antenatal record database.

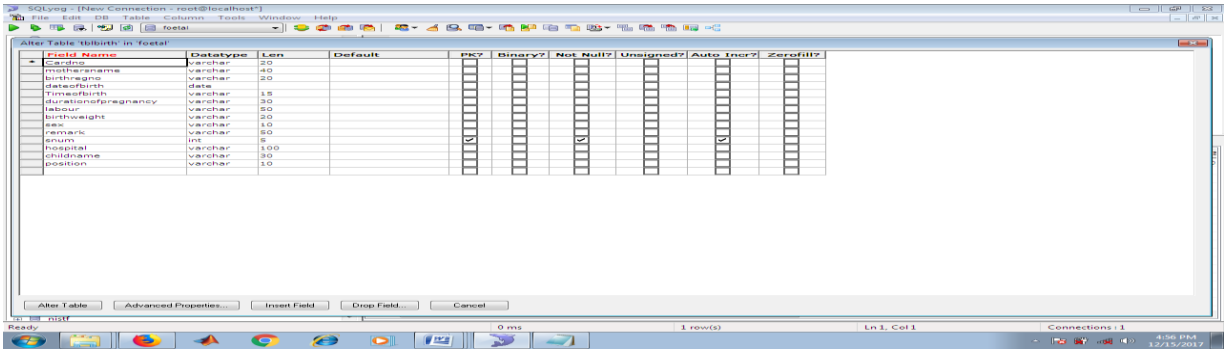

Fig. 4.19: Birth registration database table

Figure 4.19 shows the birth registration database table and this contains and birth information.

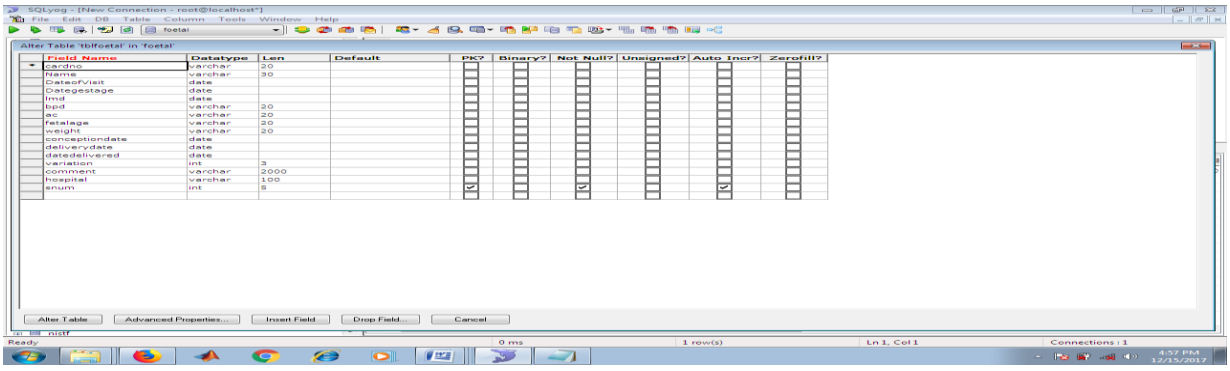

Fig. 4.20: Foetal parameters database table

Figure 4.20 shows the foetal parameters prediction table

Test Result

Module	**Expected Test Result**	**Actual Test Result**
Log In Form	Expected to see the Log In form so that one can log in.	When clicked on log in, a form appeared where you can enter your username and password.
Home Page Form	The expected result was the screen from where you can decide to call up any of the sub systems	The home page enables user to have access to other sub systems
Signup Form	Is expected to be used by pregnant mother for antenatal registration	When clicked on the sign up button, it displayed a form where the user can fill the pregnant mother record for starting antenatal clinic and the system generated a registration number automatically for each person that registers.
Hospital button	Expected to be used by hospital admin to login to the new system	This button displays the hospital admin login form where the user name and password is verified before gaining access to the restricted area
Patients button	Expected to allow registered antenatal mothers to access their data	The button displayed a form when you are required to enter registration no and phone number. Once validated, the person can view her details and all the antenatal clinic visits.
Antenatal visits button	Expected to be used to enter antenatal clinic records	The form was used to post the antenatal clinic record to the database
Foetal parameters prediction button	The button is expected to display a form where the gestational age with EDD will be predicted	The form was used to predict the gestational age and the EDD with foetal weight and BPD
Child delivery button	Expected to display a form for registering child birth	When clicked on the button, a form was displayed where the child delivery record was entered and submitted to the database
No of visits button	Expected to display the no of antenatal visit of an expectant mother	The button when clicked on displayed the record of antenatal visits of a selected expectant mother and the total no of visits

Statistical report button	It is expected to display all the registered antenatal records across various hospitals	The button when clicked on displayed all the registered antenatal records with their respective health centers and total.
Report	In this module, it is expected to be used to view report	When you go to this module, antenatal register, antenatal visit report, child birth report, and foetal parameters prediction report can be viewed
Delete button	To be used to delete record from the database	When clicked on delete button, the selected record was deleted from the table in the database
Help and support form	Expected to be used to submit help requests online	The form allows users to send request for attention or direction on antenatal issues.

CONCLUSIONS

This thesis have attempted to discuss a particular possibility of an ES to solve problems of complications primarily due to low and excessive birth weights at delivery by accurately estimating foetal parameters *(Foetal Weight, Foetal Age Conception Date, And Delivery Date)* using Ultrasonographic Foetal Biometric Data. The primary goal of expert system research is to make expertise available to decision makers and technicians who need answers quickly. There is never enough expertise to go around - certainly it is not always available at the right place and the right time. But computers loaded with in-depth knowledge of specific subjects can bring decades worth of knowledge and solution to a problem. If we must investigate and solve those utrasonographic foetal biometry method of estimation that has been described over the decades as complicated, labour -intensive, limited by suboptimal visualization of foetal structures, costly and specially requiring trained personnel, we will have to build into the estimation the use of a Computer Wizard (An Expert System).

The perception of the clinician as the final arbiter and a system's ability for clinician override has been described as crucial in clinical decision support system integration. The issues relating to the requirements for clinician control indicate that close co-operation with medical staff is crucial in the development of our system to ensure that it can be successfully implemented. Full disclosure of the assumptions involved in the design of the system is also vital. Once again this requires a close relationship between the knowledge engineer and the expert medical staff during development to ensure that clinical guidelines are understood and are being implemented correctly.

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