Diagnosing of Bleeding in Late Pregnancy: A Medical Expert System Approach Using NLP–Based Input Generating Model

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Abstract— *In medicine, the best diagnostician is held in high esteem, in the case of pregnant women correct diagnosis of bleeding in late pregnancy (after age of viability) makes a difference between life and death for the mother and/or baby. Information gathering from patient by clinicians during diagnostic procedures requires some skills to adequately collect required relevant information that will be adequate for diagnosis. Diagnosis, decision making are all areas of application of artificial intelligence. Due to inadequate obstetricians, efforts to better reach underserved communities and manage obstetric emergencies like bleeding in late pregnancy in developing countries is increasingly based on task shifting to community health workers, nurses, midwives or doctors (WHO, 2008) with high maternal mortality, and high morbidity, especially in the developing world. Research has proven that the major challenge is to ensure health providers extract, in their precise and simple form, the information needed for the diagnostic task. This paper therefore provides a formalized input generating model that addresses this shortcoming through the creation of an inference process, rule set and natural language processing (NLP). Furthermore, this research implemented the proposed input generating model to develop a text based input graphical user interface (GUI) software to diagnose the cause of bleeding with the ability for storage, retrieval and editing if need be. The results show that the proposed model will add value to the accuracy of correct diagnosis of bleeding in late pregnancy among the targeted group.*

Keywords*: Late bleeding, natural language parser, input generation, inference process.*

I. INTRODUCTION

In medicine the best diagnostician are held in high esteem, in the case of pregnant women, correct diagnosis of bleeding in late pregnancy from or into the genital tract (after age of viability) and prior to the birth of the baby make a difference between life and death for the mother and or baby. It complicates 3-5% of pregnancies [1]. Diagnosis and decision making are areas of application of artificial intelligence. Intelligent medical diagnoses are now becoming common, providing support to health care delivery [2].

The aim of this paper is to present a program that provides a ranked list of clinical diagnosis, based on a set of symptoms, to assist medical practitioners to reduce errors in diagnosis of bleeding in late pregnancy, (which is as important as reducing medication errors or eliminating wrong site of surgery) in order to reduce maternal mortality and can be deployed in low resource settings among non-specialist.

II. LITERATURE REVIEW

Obstetric hemorrhage remains one of the major causes of maternal deaths in developing countries, and it is the cause of up to 50% of the estimated 500,000 maternal deaths that occur globally each year [3]. Nigeria has one of the highest maternal mortality ratios in the world, currently at 545 per 100,000 live births [4]. Obstetric hemorrhage contributes 23% of these deaths, majority of which are due to bleeding in late pregnancy (antepartum hemorrhage), and it is a risk factor for bleeding after delivery (postpartum hemorrhage) [4]. Efforts to better reach underserved communities and manage obstetric emergencies, such as bleeding in late pregnancy in developing countries is increasingly based on task shifting to community health workers, nurses, midwives or doctors (general practitioner, family physician, doctors in other specialties or medical officers) due to inadequate obstetricians [5]. In the primary health care (PHC) centers which is closest to the communities, these categories of staff are expected to provide basic emergency obstetrics care (EmOC), and are usually the port of first call in cases of bleeding. They are expected to institute emergency care, and provide urgent referral to secondary health facilities, where comprehensive EmOC is provided. The secondary health facilities have provision for anesthesia, blood transfusion and surgery, therefore suited for management of late

pregnancy bleeding [5,6]. In all these scenarios, immediate and accurate interventions or urgent referrals to an obstetrician are required and this would depend on accurate diagnosis. Consequence of wrong diagnosis, mismanagement or delay in intervention may result in increased; cases of caesarean section, premature birth with all its consequences, incidence of blood transfusion and its consequences, cost of medical care, cases of maternal mortality and poor health indices for the country.

Diagnostic mistakes account for 15% of errors that result in harm to patients among physicians according to the institute of medicine (7). At least 1 in 12 patients who die have been diagnosed incorrectly [7]. According to Britto, [7], co-founder and developer of a new diagnostic program called 'Isabel' who estimated that doctors are wrong in about one in 15 cases said, "the problem with diagnosis is we do not know when we do not know ". Among none specialist in obstetrics, such as medical officers, Nurses/Midwives and community health officers who constitute the majority of those, who first see these women, the errors are much higher. It was observed in [8] that practicing internist, had significant difficulty, making even relatively easy diagnosis and that the confidence of the physician was not much lower, when they were wrong than when they were correct in their diagnosis. Further, because of this unjustified confidence, they did not seek second opinion or consultations [6].

Robertson channeled his vision into the creation of NxOpinion (Nx is short for 'Next'), a real time diagnostic tool built on Microsoft technology, which was launched in 2015, it provides physicians with timely, relevant information, concerning hundreds of non-chronic illnesses and diseases [6].

DXplain is a popular diagnostic software tool for physician, which is free on the Internet, to every licensed health care provider in the USA [9]. It allows the clinician to plug in patients' symptoms and demographic information, such as sex, age & race. The computer then compiles a list of possible diagnosis & the doctor can click for more information [9].

III. Methodology

In this section, the proposed model of the expert system is presented. Furthermore, the algorithm of the system is discussed.

A. The Input Generating Model

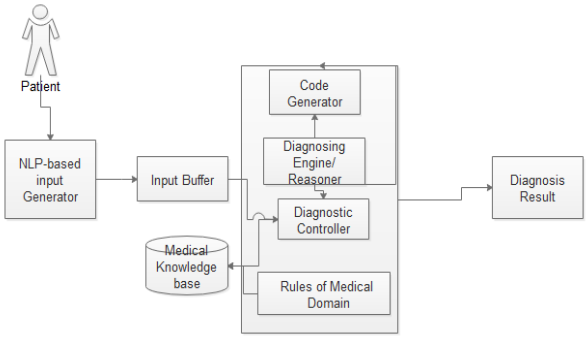

Figure 1: Model for diagnosis of bleeding in late pregnancy

Inputs: Inputs to the system are in two broad forms: text and images. Text shall consist of data items like patients' names and addresses, patients' data and symptoms presented by patient. Images are patient's photos. Text inputs shall be captured via the keyboard, while images are expected to be scanned and stored on disk, from where the software shall be able to read them and store them in the database. Note that our image inputs are strictly patient's passport which its use is simplified to display purposes.

The natural language input generator interfaces the user and the expert system. The patient is expected to submit the tuple<b, S, h> where b is patient's biodata, S is a set of manifesting symptoms, and h are other medical history of patient. The NLP-G then employs the use of an expert designed knowledge base (KB) and an inference engine (IE) to deduce the meaning of the components of the tuple<b, S, h>. Hence, the input generator which produces a set of M manifestations for input into the system may be denoted by equation 1.

$$\{M\} = \text{NLP} - \text{G}\,[\,[\text{KB}, \text{IE}]] \leftarrow \text{tuple} < b, S, h> \quad [1]$$

Processing: Prior to processing by the expert system, the input generated by the NLP-G is buffered in an input buffer. Passport images shall be stored as supplied. However, they shall be temporarily resized in order to make them fit properly in their place-holders. At the heart of the processing by the expert system is the diagnosing controller (DC). This module reads in input from the buffer and then channels them to the diagnosing reasoned (DR). Also, DC plays the role of knowledge retrieval from the domain knowledge base (KB). The data retrieved from KB are systematically piped to DR for reasoning support. Meanwhile, DR applies the rules in coordinated rule set (CRS) in reasoning over the set M in the domain of KB. Note that CRS and KB forms the knowledge framework (KBF) of the expert system. These can therefore be model thus:

$\{ s \mid s \in M \text{ and } M \in KB\}$ [2]

$\{ r \mid r \in CRS \in KBF\}$ [3]

The operation of DR is denoted by:

$$DR \rightarrow KBF(KB + CRS) \circledast L \quad [4]$$

Assuming L is a set of logic statements that acts on the knowledge base represented in the knowledge framework.

Outputs: The software produces various outputs and displays them on screen as well as print hard copies. Outputs required from the system shall include diagnosis cards, entire list of patients and the result of the diagnosis.

Assumptions and Dependencies: A key general assumption is that prospective users of the product shall have very basic operation knowledge of a Microsoft Windows-based PCs (i.e., how to boot up and shut down the system properly; how to use the mouse, and how to navigate menus). It is also assumed that target beneficiaries of the software (i.e. health practitioners) shall already have at least one functional PC and a printer in place, to use the software plus (needless to say) a reliable power supply.

B The Algorithm of the Expert System

Algorithm 1: Algorithm for diagnosing bleeding in late pregnancy

```
1   generate user unique code
2   let Q be an array of questions to prompt user
3   WHILE Q not exhausted
4       q1 ← Q
5       ans1=prompt user to respond to q1 question
6       buffer ans1
7   END WHILE
8   input_token=NLP_Engine (all ansi)
9   M ← buffer input_token
10  read pregnancy medical database into KB
11  medical_reasoner (KB, input_token, CRS)
12  display result
```

The procedure of the late bleeding diagnosing expert system is model in Algorithm 1. First, the algorithm assigns a unique code of identification to every user. A while loop then guides the user through a pool of questions/prompts, with each question read and stored by the statement $q_1 \leftarrow Q$ on line 4. Thereafter, the result of NLP-G is collected from the user input which itself is generated from a set of questions/promptings. On line 9 of the algorithm, the buffer is loaded with the output of NLP-G as discussed earlier. Furthermore, the operation defined by equation (4) is executed on line 11 of Algorithm 1. Finally, the result of the diagnosis is displayed on line 12.

User interfaces is GUI-based. Data capturing is done through graphical windows with all the necessary widgets (textboxes, drop-down combo boxes, list boxes, command buttons, etc.); and messages shall be communicated to the user through graphical dialog boxes. Menus **shall** provide the means by which users can make choices while using ***the*** system. A command-line user interface is not required.

B. Description of Diagnosis Reasoner (DR)

Identification: form Main
Type: Multiple Document Interface (MDI) form
Purpose: The main MDI screen serve as the application's main window.
Function: It provide a complete menu system through which users can navigate and choose tasks to accomplish.
Subordinate: This screen contain links to all other forms that provide the various functionalities of the application.
Dependence: the main form is automatically loaded.
Interfaces: interface with the logon form through which it is loaded on the one side, and it accepts, interpret and pass on user's service those user requests on the other side.
Resources: No special resources required
Processing: It processes user requests and translate them into concrete actions that will allow user to perform productivity tasks.
Data: Data shall be in the form of mouse clicks, which shall be appropriately interpreted for action, and direct entry field.

External Interface Requirements Specifications

Hardware Interfaces: Other than the main system unit, the proposed system shall interface with a desktop printing device, (like HP LaserJet or HP Desk Jet series) to produce hard copies of various documents. It is not required to directly interface with image scanners, digital cameras, or mobile phone devices.

Software Interfaces: *T*he software is able to interface with Microsoft Office suite of applications to produce extended reports. Specifically, it shall interface with Microsoft Excel to produce graphs and charts based on data that is queried from the database tables; and it shall interface with Microsoft Word to enable users print the user reference manual and other documents that might be bundled with the final software. The database tables themselves shall interface with Microsoft Access JET engine (ODBC 4.0).

Communications Interfaces: The system is not required to interface with any communication device (modems, telephones, etc.).

IV. *IMPLEMENTATION OF THE PROPOSED MODEL*

Bleeding in late pregnancy was developed using Visual Basic 6.0 and compiled into *Pregnancy Diagnosis.exe*. Macromedia Fireworks was used as the graphic tool and Microsoft Office Access was the database used in order to be able to store and retrieve information. The software "Pregnancy Diagnosis.exe" setup was created for those who do not have a Visual Basic Setup.

Figure 2: Personal Details Menu

Figure 2 shows the form to be filled by the health provider. Click on upload pictures to select the patients picture which has been saved in the computer, and after that, click on submit.

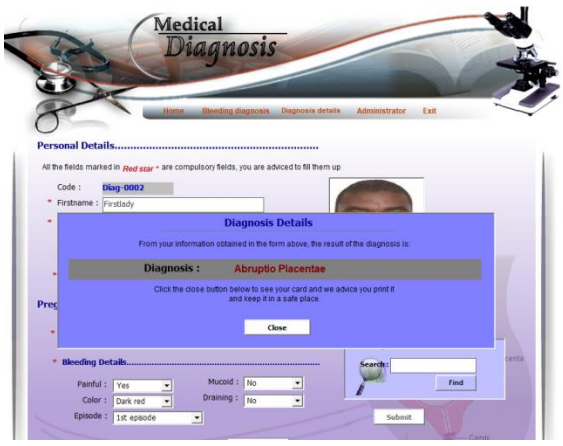

Figure 3: Diagnosis Details

Figure 3 displays the diagnosis generated after submitting the form and it is stored automatically.

V. DISCUSSIONS

The primary step to using the software is to setup the "**Pregnancy Diagnosis.exe**" or double click on the file "**Project1.vbp**" on the installed Visual Basic compiler/interpreter, when it opens, hit the **F5** key to run the software. Figure with the options Home, bleeding diagnosis, diagnosis details, administrator and exit will appear, click on bleeding diagnosis then Figure 2 will appear. On the lower right side of the page is the *New* menu, once you click on it, a number 001 will appear as code number. Each time you have a new patient; click on new to generate another number serially. Fill in the name and address then the age is generated by feeling in the day, month and year of birth, for instance, 24years in this case.

Next is the pregnancy detail as seen in the drop down box which is 7-10 months. Click on one of the items based on the gestational age of the pregnancy. The next after this is the five options, each with simply yes or no in the drop down box selected as appropriate, then upload a picture of the patient stored in the computer and click on submit. This will bring out a dialog box asking if you are sure you want to submit click yes or click on no, to make changes. If yes is clicked, it will bring out the diagnosis as shown in Figure 3. Click on close, the dialog box will appear telling you the details have been added.

If you are not interested in the name, age duration of pregnancy but just the diagnosis, then select 'bleeding details' from the home page, there are five bleeding options of yes or no regarding painful, color, episode, mucoid and draining select as appropriate, then click ok and it will show the diagnosis. If you *click close* below the diagnosis, the diagnosis will disappear leaving the five options so you can feed in symptoms appropriate for another patient. To exit the page, click back, it will go back to the home page.

VI. RESULTS

The result using the expert system for diagnosing bleeding in late pregnancy, was compared with the results of diagnosis among non-specialist using the traditional method, see Table 1

Table 1: Comparing the performance of the proposed system with the traditional method

	Comparison Parameters			
Research Work	**Accuracy**	**Precision**	**Computation Time**	**Recall**
This paper	**80%**	**80%**	**7minutes**	**100 %**
T. Method	**30%**	**20%**	**30-60minutes**	**30%**

Two groups of medical officers, one using their knowledge (traditional method) the other using this software mounted on a PC in two different outpatient departments, until each had seen 20 cases, there diagnosis was confirmed either by an obstetrician or using an ultrasound or in theatre as the case may be seen in summary of result in Table 1 after the average of the time needed to make a diagnosis was found for the two groups. If their diagnosis was exactly what they said it was it is regarded as accurate, but for the traditional method, they were allowed to make two diagnoses when they are not sure, if either was correct it is regarded as precise. And when it came to recall the traditional method depends on tracing the folders of the patients some were missing maybe due to misfiling we were only able to trace six out of twenty but for those on the PC we were able to recall all at any time. Medical officers were used in this study, if paramedics whose knowledge base is far below those of doctors were used, the difference would have been more marked than what we have in table 1 especially with the traditional method

VII. CONCLUSION

It is a novel idea targeting low resource settings and it is obvious from the table that it will add value to the challenge of accurate diagnosis especially among this group of health worker. It is designed for three installation options as follows: standalone installation on individual personal computers, by active server pages (an application hosted by logical images accessed over the Internet by client software on the user personal computer) and via the Web Server (an application hosted on the user's server and accessed over an intranet by client software on the user's personal computer). It has a friendly input graphic user interface (GUI) and can be used by any computer literate person, with minimal or no training. If deployed, it will help in reducing maternal and perinatal morbidity and mortality, and the parameters can be edited to reflect new definition.

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