Graphical User Interface (GUI) of Digital Index Evaluation System for Finger Clubbing Identification

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ABSTRACT

This paper presents the development of a Graphical User Interface (GUI) for calculating the sum of nail-fold (NF) and distal interphalangeal joint (DIP) ratios for all ten fingers. The sum of NF:DIP ratios for all ten fingers leads to the Digital Index (DI) that was used as the measure for identifying and determining the presence of finger clubbing symptom. This GUI system was developed to serve as a simple and user-friendly interface for clinicians to calculate DI value of patients in a busy clinic practice. It is also equipped with the capability to keep the patient's past diagnosis medical check-up data for future monitoring purposes. The result shows that the developed system helps the clinicians to perform calculation of DI value and identify the presence of finger clubbing in a very short time. The average time taken to measure both NF and DIP circumferences using Finger Clubbing Meter, and to compute DI values using Digital Index Evaluation System (DIES) interface is 6:36 ± 1:24 minutes (Mean ± SD) .This system is expected to contribute in detecting the finger clubbing problem at early stage of so the treatment can be performed immediately.

Keywords: *finger clubbing, digital index, nail-fold, distal interphalangeal joint, graphical user interface*

INTRODUCTION

Clubbing or finger clubbing indicates the enlargement of the distal segments of the fingers, reduction in the nail-fold angle, and sponginess of the nail beds [1]. Clubbing is associated with a number of diseases including pulmonary, cardiovascular, hepatic, thyroid and gesindicates. It was also known as nail clubbing phenomenon where an individual experiences deformity in the fingers, in which the occurrence of focal and bulbous swelling of distal phalanges is accompanied by the alteration in nail bed's angle [2-4]. Finger clubbing causes the nail-fold angles, shape, depth, and width of the terminal phalanges of the fingers to grow in an abnormal manner [2].

Clubbing severity can be classified according to different grade (one to five) according on how different it is to normal fingers. Table 1 shows the grading of clubbing [5]. An advanced or end stage of clubbing is extremely easy to detect through physical examination, as evidenced by the presence of 'drumstick fingers' even though the vital signs of primary hypertrophic osteoarthropathy (HOA), for instance were within normal limits [6-7]. However, signs of finger clubbing may be difficult to identify in the early stage of the disease. Several objective criteria have been developed in the past century to quantify clubbing including measurement by material brass templates with arcs of various sizes, plethysmography, digital casts, and shadowgraph technique [5].

All these methods are relatively crude and cannot be accepted as standard as they do not provide easy quantification [5].

Table 1: Grading of Clubbing [5]

Grade 1	Fluctuation and softening of the nail bed
Grade 2	Increase in the normal 160o angle between the nail bed and the proximal nail fold
Grade 3	Accentuated convexity of the nail
Grade 4	Clubbed appearance of the fingertip
Grade 5	Development of a shiny or glossy change in nail and adjacent skin with longitudinal striations

Two objective measures for identifying and assessing the presence of clubbing have been proposed [8]. The first objective measure is recognised as phalangeal depth ratio. It measures the ratio of distal phalangeal depth (DPD) to interphalangeal joint depth (IPD) of index finger. The DPD:IPD ratio higher than 1.0 signifies the presence of clubbing. The second objective measure, known as digital index (DI), measures two separates circumferences on each of the ten fingers at the nail fold (NF) and the distal interphalangeal joint (DIP) [8], as illustrated in Figure 1 [9]. The sum of NF:DIP ratios for all ten fingers determines the DI. The digital index of 10.2 or higher signifies the presence of clubbing [8]. This study will be focusing on the DI as the objective measure.

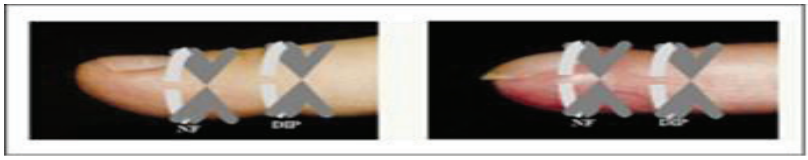


Figure 1: NF and DIP Circumferences of A (a) Normal Finger, (b) Clubbed Finger [9]

The traditional techniques of measuring NF and DIP circumferences manually using Vernier calliper and string to measure DI value has been carried out by Djojodibroto [1] on 23 male and 21 female subjects. The average time taken to take 20 measurements and calculate DI value for each subject was 35:97 ± 9:16 (Mean ± SD). This was regarded as either too time consuming or ineffective for an extremely busy clinic.

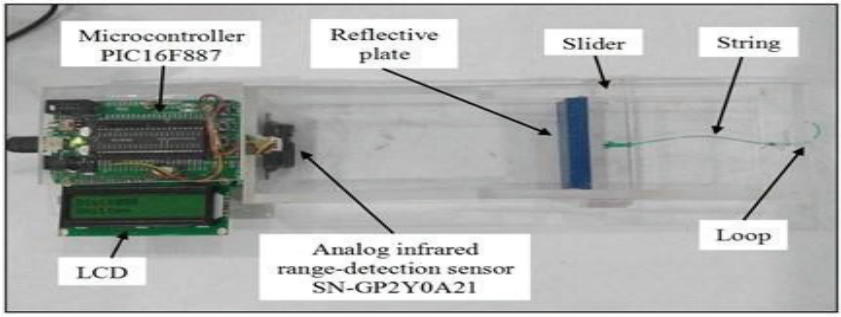
This paper will present the design and development of a simple Graphical User Interface (GUI) for finger clubbing evaluation system based on digital index assessment. The system, called as Digital Index Evaluation System (DIES) is meant for facilitating clinicians in investigating and identifying the early stage of finger clubbing encountered in patients. The availability of this system in clinic or wards will hopefully aid the clinicians and enable a faster clinical response. If the primary process is identified and treated, clubbing usually reverses completely [10].

METHODS

Digital Index Evaluation System (DIES) interface was designed using a Microsoft Visual Basic (VB) GUI. Its function includes the storing, processing and analysing of data. All the data of NF and DIP circumference measurements were collected using Finger Clubbing Meter prototype, which was built by Masra [9], as shown in Figure 2. Development of the prototype was based on the objective and concept of the earlier method and materials used by Djojodibroto [1, 11]. However, some improvement process on the design and prototyping the device is ongoing by evaluating other researchers' works in [12-13].

Description of the Finger Clubbing Meter Prototype

The primary aim of the developed prototype was to provide a digital circumferential finger measurement device for medical use, to effectively measure the NF and DIP of a finger. It took a measurement of a finger circumference by adjusting a string loop that was attached with the reflective plate after one's finger was properly fitted into the loop. The analogue infrared range-detecting sensor detected the distance of the reflective plate embedded in the prototype, where this value was the corresponding representation of the measured circumference. The value then displayed through the liquid crystal display (LCD) for data collection and analysis using the developed GUI. The detail of the prototype development and the protocol to use can be obtained by contacting the corresponding author.



Development of GUI

The major elements of this GUI interface consists of:

1. Test Box - For displaying messages
2. Button - For performing the operation
3. Input text box - For inputting all the data which is patient's detail information such as NF and DIP measurement.

Figure 3 illustrates the flow chart of the software programme that has been developed in this study.

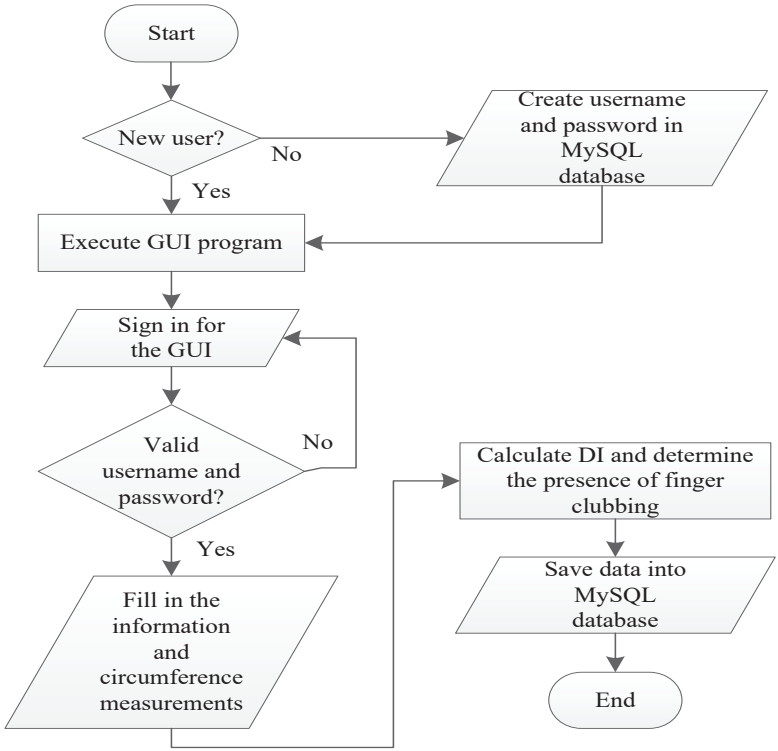


Figure 3: The GUI Flow Diagram

RESULTS AND DISCUSSIONS

The most important task of the development of Digital Index Evaluation System (DIES) was to build the GUI interface. The GUI will help the clinicians to replace manual computation of DI value, as well as manual patient record keeping system by computerised calculation and electronic-based record keeping system. This system deals with all the limitations of health records maintained on paper as discussed in [14]. Many needs and requirements must be considered in developing user interface of medical devices as elaborated in [15].

Signing in to DIES

New username and password were allocated to a new user / clinician for a valid access to the system. The user will be prompted to log in for accessing the system, as shown in Figure 4. If the username and password inputted are valid, the user will be prompted to the main form of the GUI programme.

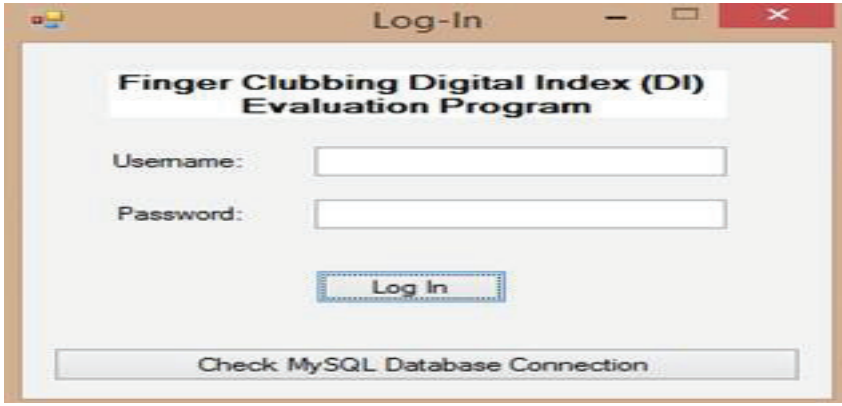


Figure 4: Log-in Layout

Button 'Check MySQL Database Connection' was created in the GUI Log-In form for checking the connectivity of the GUI programme to MySQL database. If the GUI is connected to the database, the GUI will function properly and clinician will be allowed to access the Main form

and use the programme upon the matched username and password. The button will show the message that indicates established connection with MySQL database. Otherwise, error message will be displayed to indicate the possible problems in the connectivity.

Subject (Patient) Information

The Subject/Patient layout will be appeared once the clinician has logged in to DIES, for the purpose of creating data for a new subject / patient or selecting analysis data for same subject. Figure 5 illustrates the 'Subjects' layout.

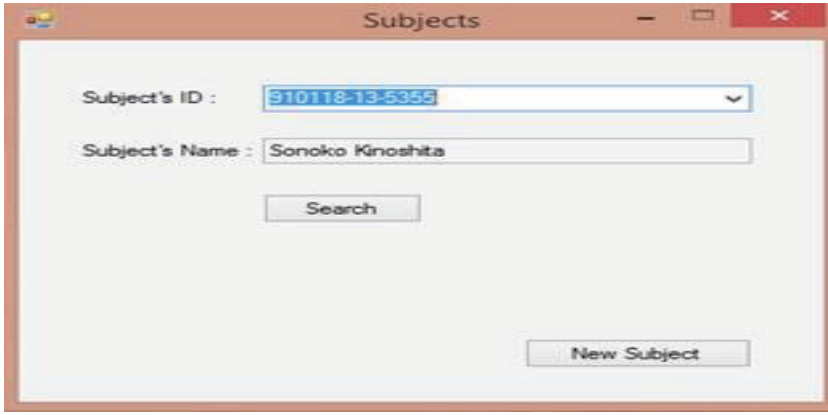


Figure 5: Subject (Patient) Layout

Main Layout

Then, the clinician will be led to the GUI 'Main' layout of the system. Figure 6 illustrates the general overview of the GUI Main layout. There were three main components available in the 'Main' layout. The subject/patient particulars that were located on the left side of the 'Main' layout displayed the following information: patient ID, name, gender, and age. The table of data that was located on the right side of the main layout displayed the saved data. The third component was the finger clubbing computation textboxes, buttons, DI value indicator, and diagnosis result indicator.

For diagnosis of a new subject/patient, the basic particulars were required to be entered by the clinician in the provided text boxes. Upon completion in filling these particulars, the clinician will have to click on the 'New Data' button, in order to save these new data into the database and display them at the data table of the GUI Main layout. The date and time will be recorded automatically, which were saved according to the time displayed at the 'Main' layout.

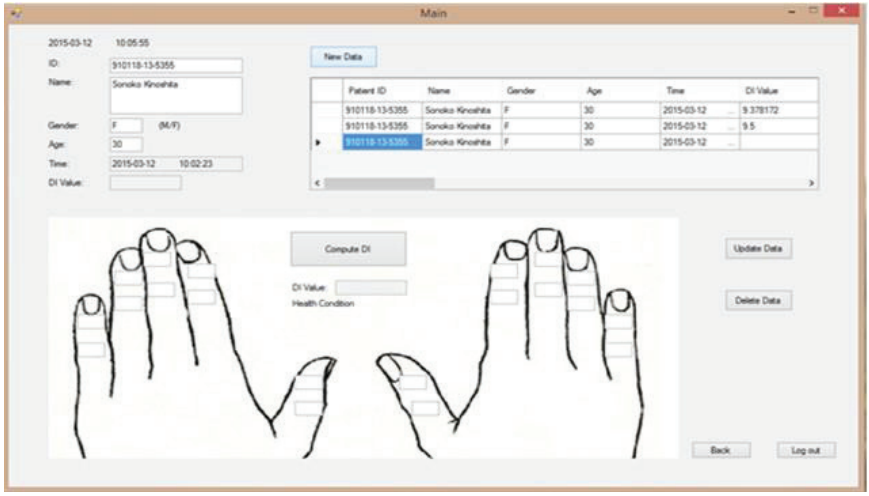


Figure 6: Main Layout of DIES

The clinician will then enter all the NF and DIP circumference measurements of each finger obtained by using the developed prototype [9] into each respective text boxes shown at the hands graphic image of the GUI Main layout. The unit used was in millimetre (mm). The text boxes have been placed at the location corresponded to the position of the NF and DIP of each finger, as shown in Figure 6, for the purpose of simple and straightforward verification and identification. The hands graphic image helped in preventing the mistakes and errors while entering the data.

DI Value Computation

Upon the completion of filling the NF and DIP measurements into all twenty respective text boxes, the clinician will have to click the 'Compute DI' button in order to calculate and display the DI value result at the readable-only text box. A digital index of 10.2 or higher signifies the presence of finger clubbing. The system performed the calculation of DI using data as tabulated in Table 2 and Equation (1) [9].

Table 2: Measurement of NF and DIP for All Ten Fingers

Left hand finger	NF (mm)	DIP (mm)	Right hand finger	NF (mm)	DIP (mm)
Thumb	a	f	Thumb	k	p
Index Finger	b	g	Index Finger	l	q
Middle Finger	c	h	Middle Finger	m	r
Ring Finger	d	i	Ring Finger	n	s
Pinky Finger	e	j	Pinky Finger	o	t

$$\mathrm{DI} = \frac{a}{f} + \frac{b}{g} + \frac{c}{h} + \frac{d}{i} + \frac{e}{j} + \frac{k}{p} + \frac{l}{q} + \frac{m}{r} + \frac{n}{s} + \frac{o}{t} \qquad (1)$$

For a case of healthy subject with diagnosed DI value of less than 10.2, 'DI Value' text box showed the DI value and notification saying that "You have no clubbed fingers", as shown in Figure 7. However, for a case of the computed value was greater or equal to 10.2, the notification on the presence of clubbed fingers will be appeared, as shown in Figure 8.

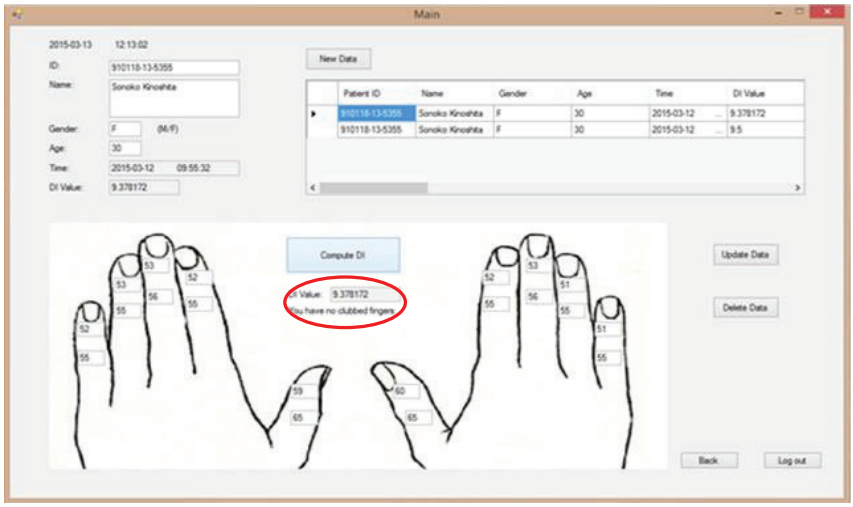


Figure 7: Notification on the Absence of Clubbed Fingers

Next, the clinician will have to click the 'Update Data' button for saving the DI value into the database. Once it was saved, it will be displayed automatically at the data table of the GUI Main layout. After the completion of all the desired diagnosis and finger clubbing evaluation, 'Log Out' button was clicked to exit the GUI Main layout.

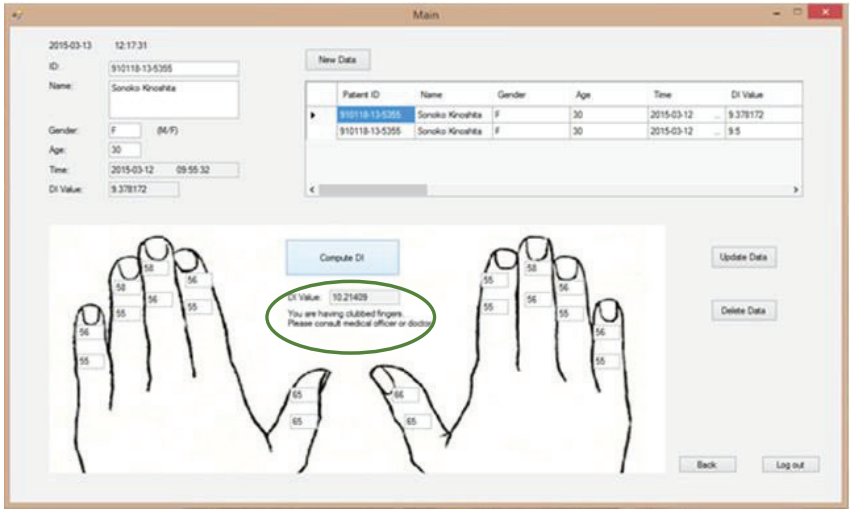


Figure 8: Notification on the Presence of Clubbed Finger

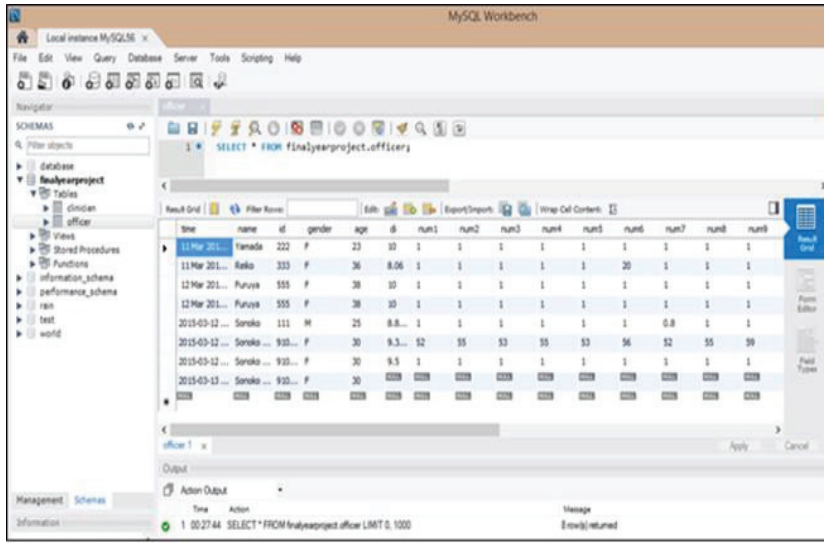


Figure 9: MySQL Database Showing the Successful Saving of Data

The data saved can be reviewed and checked at MySQL Workbench software programme. Figure 9 shows all the data that have been saved successfully into MySQL database. Once a new data was saved into the database, the clinician was able to observe the change in the data record by simply clicking the 'Refresh' button on the top of the database table in MySQL database software. The 'NULL' data table cell entry will be altered and overwritten to the respective data saved by the clinician.

Table 3: Comparison of Time Taken using Two Different Measuring Tool

Device and Method	Time taken (min) (Mean ± SD)
String and Vernier calliper & Manual calculation [1]	35:97 ± 9:16
Finger clubbing meter prototype & DIES interface	6:36 ± 1:24

CONCLUSION

In this study, the GUI interface of Finger Clubbing Digital Index (DI) Evaluation System, called as DIES has been successfully developed using Microsoft Visual Basic. This interface provides an easy-to- use system to calculate the sum of NF:DIP ratios for all ten fingers in a very short time. Table 3 compares the average time taken to measure both NF and DIP circumferences using traditional technique and manual calculation of DI, with the developed prototype and calculation of DI using the GUI interface. The time taken of 6:36 ± 1:24 min (Mean ± SD) shows an efficiency of the interface. Hopefully, the availability of this interface will help the clinicians to identify the early stage of finger clubbing among patients and eliminate the need for manual calculation of the DI value. This saves times and minimises clinicians' errors, while offering an efficiency in a busy clinic practice.

ACKNOWLEDGEMENT

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