DEVELOPMENT OF A CONTROL SYSTEM FOR LASER DOPPLER IMAGING SCANNING TECHNIQUE USING LABVIEW

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***Abstract*--To monitor a small region of skin tissue for blood perfusion mapping construction, a Y-Z scanning control system using X-Y mechanism was developed. This control system utilizes the combination of a Stepper Motor and a DC Motor. A GCP (Graphical Coded Programming) of LabVIEW is used to compute the system driver controller via DAQ (Data Acquisition) card of PCI E-series. The results presented are based on experimental observation. Results show that the design is capable of performing the Y-Z scanning pattern up to 25 mm x 25 mm AOI (Area of Interest).**

I. INTRODUCTION

Numerous studies have been developed in designing control system as a scanning tool for measuring different non-ionizing radiation, reflected by the intensity of light wave which gives rise to blood perfusion mapping. The information inherent to the returning of photon signals is perpendicular to the scattering technique on a cross-sectional area shown in Fig. 2. The visible data is than analyzed, processed and to be displayed near real-time. Selected visible data is then presented into two dimensional of threshold parameter which is known as Imager. Grayscale imager is presented as the property of image scanned. An LDPI (Laser Doppler Perfusion Imager) that was reproduced with permission, Lisca AB, Sweden by the University of Limerick and LDI (Laser Doppler Imaging) system developed by Moor Instrument, are the unique designs towards better healthcare diagnose specifically on burn depth assessment [3,4,5]. In addition, these new techniques help to fulfill the clinical requirements of a sensitive, continuous, non-invasive and real-time method for the measurement of microvascular blood flow [3,4,5]. However, technique like these; LDI and LDPI are too expensive for developing countries to purchase. Therefore, an alternative approach that is economical with specified limitation hence performed similar capabilities and responses are developed. Fig. 1 presents the complete work.

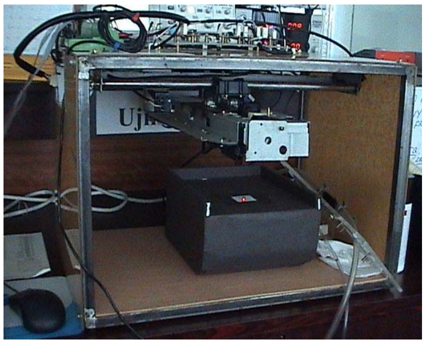

Figure 1. Prototype design for blood perfusion mapping with built in "Scanning Control Unit, SCU" and "Calibration Control Unit, CCU" units.

II. METHODS AND MATERIALS

This paper proposes economical scanning system, as it ensures information can be directed in a full scale with minimal losses. The paper investigates scanning method using Y-Z direction with respect to time. A GUI (Graphical User Interface) is applied in the system as interaction platform between GCP and scanning mechanism.

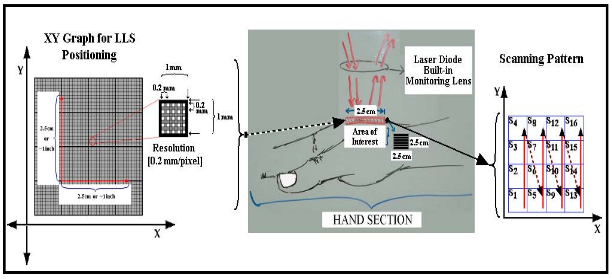

Figure 2. Targeted "Area of Interest, AOI" and scanning pattern.

In order to improve scanning distribution accuracy, the LLS (Linear Light Source) of visible

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infrared is directed to an initial coordinate of x=0 and y=0. This is known as RPC (Reset Point Calibration). Based on experiment observation, an RPC is a must to ensure AOI is measured in full scale and can be easily referred. Fig. 2 presents the targeted AOI as in hand section using XY graph paper to monitor the scanning pattern of Y-Z technique.

A. *Scanning Control Unit*

The system consists of two identical parameters used to perform the scanning technique based on requirement. An XDCU (X-axis Direction Controlling Unit) and an YDCU (Y-axis Direction Controlling Unit) are the parameters mentioned.

B. *XDCU (X-axis Direction Controlling Unit)*

This unit consists of elements involved in simulate X-axis linear direction and its driver controller. Stepper Motor is used in the design to perform XD (X-axis Direction) because the characteristics of Stepper Motor are suitable to be used for the movement involving in a back and forth steps across an AOI. Moreover, it is required to measure each predefined AOI in millimeter scanned. The default scan value per millimeter scanned is 0.2mm per pixel at 2.5cm equivalent or approximately to 1 inch. This is a standard scanning resolution practice for most Laser Doppler Units. Immediately after the first YD (Y-axis Direction) mode computed completed, the first half-step CW (Clock Wise) of step angle 3.75°steps of the XD mode scanned is from left to right. When the edge of that first scanned end point of XD mode is reached, it is then delayed for a few milliseconds before computing the following process. During the time delay, dc motor computes as in CW mode followed by CCW (Counter Clock Wise) mode as programmed in the GCP.

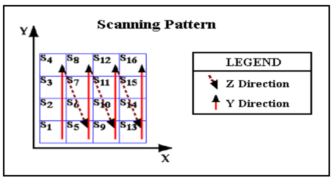


Figure 3. Scanning pattern.

The next and following scan of XD compute the similar sequence as described earlier. This process continues until the entire surface has been scanned based on the scanning pattern mode programmed as shown in Fig. 3. The driver unit indicated in the electronics system is the IC (Integrated Circuitry) push-pull 4 channels driver without diode for smoothing stepper movement. While the Stepper Motor used consists of 4 poles (coils) unipolar winding of 6 pins which is to be applied to digital input/output of DAQ card for data manipulation. Fig. 4 presents the interfacing and driver units, and also a Stepper Motor used as a complete system for XDCU.

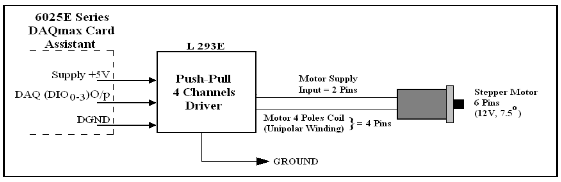


Figure 4. X-axis linear direction controlling unit.

C. *YDCU (Y-axis Direction Controlling Unit)*

A DC Motor is used in the design to perform Y-axis linear direction. This is because a short period of time delay of PWM (Pulse Width Modulation) can be produced during an open loop movement. Thus, to perform scanning operation, the DC Motor is computed to rotate in CW and CCW mode via DC Motor driver controller. The controller consists of an open collector buffer and a reed relay. Since single DAQ is used in the design, information may collide during the experiment. This is due to the signal conditioning performance of DIO (Digital Input Output) FIFO (First In First Out) of 8 digital lines functionality. In order to solve this, time delay between DC Motor and Stepper Motor are set to a difference of 38%. At the RPC, the DC Motor is computed to rotate CW before CCW. During CCW, Stepper Motor that presents XD is computed to rotate in a half-step CW of a 3.75° step angle. As a result, movements of DC Motor during CCW and Stepper Motor during CW produced the Z-axis directions. Consistent and accurate scanning movements are required continuously during scanning construction.

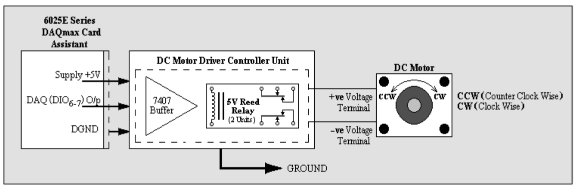


Figure 5. Y-axis linear direction controlling unit.

The DC Motor driver circuitry requires high voltage/current to initiate the permanent magnet –

stator to rotate the rotator device to CW and to CCW directions. The driver circuitry consists of an interfacing unit, an open collector 7407 Buffer ICs, a Reed Relay and also a DC Motor as a complete system for YDCU as shown in Fig. 5.

D. *LabVIEW Programming for Scanning Pattern*

The SCU (Scanning-pattern Control Unit) is an important application to be used in any LDI (Laser Doppler Imaging) instruments. Fig. 6(a) represents the VI (Virtual Instrument) block diagram of GCP for controlling unit and Fig. 6(b) represents its FP (Front panel) of GCP for GUI. Both figures are used for the SCU to perform the YZ direction scanning pattern. Referring to Fig. 6(a), the GCP present AF (Arithmetic Functions), which consists of Numeric, Boolean and Compare functions, used in most of the data build in the program. These data can be manipulated to perform the YZ scanning pattern. Since, DAQ assistants' tasks are required to create, edit and run various tasks using DAQ digital inputs/outputs terminal, a WL (While Loop) structure as shown in Fig. 6(a), is used to repeat the sub-diagram inside it until the conditional terminal receives a particular Boolean value to stop operating. The data that execute before the FN (Formula Node) of upper level of Stepper Motor as in Fig. 6(a), are used to drive the Stepper Motor to rotate in CW mode or CCW mode. They are also used to display error produced in the close loop ring of Stepper Motor XDCU. The data that execute from the FN of Stepper Motor are used to perform numbers of count that have been made while Stepper Motor rotating on either mode and to indicate stops rotating sign. Whereas, the data that execute before the FN of lower level of DC Motor as in Fig. 6(a), are used to drive Boolean function located in the case structure within the FL structure to stimulate DC Motor to rotate in CW or CCW mode.

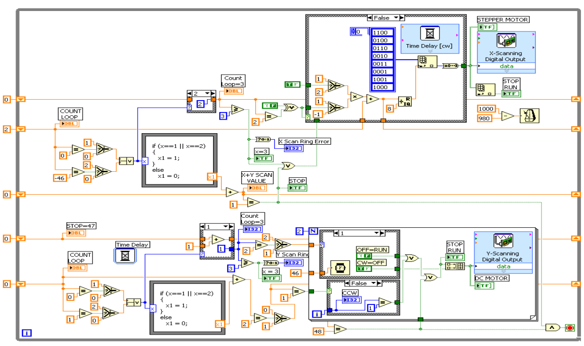


Figure 6(a). The "Virtual Instrument, VI" block diagram for "Scanning Control Unit, SCU" units

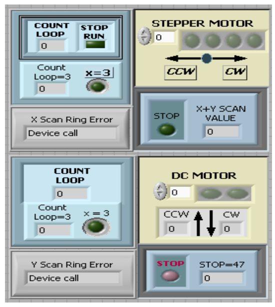
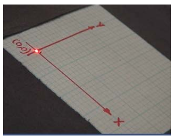


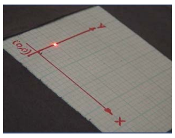
Figure 6(b). The "Graphical User Interface, GUI" of LabVIEW "Front Panel, FP" for "Scanning Control Unit, SCU" units.

Hence, the data that execute from the FN of DC Motor are to display their rotation and to indicate the control status as well as to stop from continuously functioning. The differences between the times delays of YDCU to number of loop counts of XDCU, automatically produced a pattern for scanning technique. As mentioned previously, the difference is 38%. In conjunction, the main time delay within the WL structure is set up to 2 seconds for complete scanning results. A complete scanning resolution is 25 mm x 25 mm, which is approximately to 1 inch x 1 inch by default. This is a standard scanning specification of a physical dimension for AOI scanned. With a pixel dimension of 256 x 256 and a pixel resolution of 15625 dots per inch, the default value of 25 mm x 25 mm is the best-targeted AOI. The combination of XDCU and YDCU are suitable to perform the YZ scanning pattern solution.

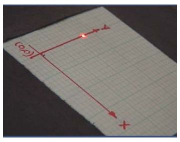
III. RESULTS

Based on observation, as in GUI of FP, the SCU can be configured to fulfill user requirement for a specified AOI scanned. However, as show in Fig. 6(b), the scanning parameter has been set to a default values for convenient during the experiment. The SCU parameter can be selected between 25 mm x 25 mm and 20 mm x 20 mm. The spatial resolution produced is up to 256 x 256 pixels: 0.2 mm/pixel at 25 mm x 25 mm area scanned is considered as normal scan. The results from the scanning experiment are show in Fig. 7 (a)-(f). Fig. 7 (a)-(c) represent the scanning pattern moving in Y direction from RPC of 0.2 mm/pixel of visible LLS per scan area to 25 mm length. While Fig. 7 (d)-(f) represent the movement of both DC Motor and Stepper Motor controlling units' results. The result of the scanning pattern produced Z pattern scanned.



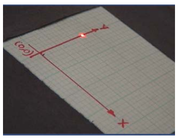


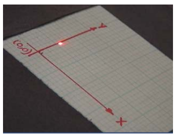
(a) 0.0 mm - 0.2 mm (b) 0.2 mm -10 mm



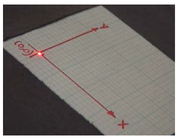
(c) 10 mm - 25 mm

Figure 7(a)-(c). Scanning pattern in "Y-axis Direction, YD" at "Reset Point Calibration, RPC" at 0.2 mm/pixel of Infra-red "Linear Light Source, LLS" towards 25mm of default value (a), increasing in unit at 10 mm (b) and reaching default value of 25 mm (c).





d) 25 mm (e) 25 mm -12 mm



(f) 0.2 mm – 0 mm

Figure 7(d)-(f). Scanning pattern in Z direction towards X-axis of 0.4 mm from 25 mm of default value (d), reducing in unit at 12 mm and drifting towards 0.4 mm of X-axis (e) and reaching X-axis of 0.4 mm (f).

The movement of hardware mechanism sequences has fulfilled the requirements of the programming coding via GCP. Tailoring to the binary array index to drive the Stepper Motor for half step sequences is much accepted compared to full step sequences. This is due to the occurrence of vibration at the positioning frame table for a loading more than ½ kilo at a speed less than 970 to 980 steps/second with the number of step angular per resolution between 59 to 79, when full step is applied. Since 2 scanning sizes, 20 mm x 20 mm and 25 mm x 25 mm can be applied, this shows that the system parameter can be customized to any scan size. However, highlights on limitation must be considered. The scanning performance due to modification of scan size depends on the VI setup at the configuration properties of VI DAQ Assistant within the block diagram builder (Fig. 6(a)).

IV. CONCLUSION

This is an on-going research work, to develop an economic Laser Doppler Imaging system in monitoring and measuring microcirculatory of blood flow near real time. Conducted researches have shown that the proposed methods to scanning pattern, arithmetic control using LabVIEW programming and also confirmed adequacy of proposed features description improve in constructing data for 2D gray scale image. Further development of the overall system is in progress.

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