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Design of Firmware and Software Application for Motion Control of Multi Leaf Collimator in Radiotherapy using compactRIO-9025 as controller

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Abstract- **Radio therapy is a widely used technique for cancer treatment, in which the cancerous cells are treated by irradiating them through high intensity radiations, while minimizing the amount of radiation absorbed by the healthy tissues.**
Since usually the area of the patient's body to be treated is not rectangular additional shaping is required and Multi Leaf Collimator (MLC) is the tool used for the purpose. In order to achieve this aim the MLC is provided with movable leaves of high density material (tungsten) and the design proposed in this paper for the motion control of the leaves is through NI compactRIO(cRIO)-9024 Real Time controller and LabVIEW.
The software part which is being designed to run on the cRIO target involves usage of three different tools namely- LabVIEW professional development software, LabVIEW FPGA module and LabVIEW Real Time module. The paper gives the detailed idea of operating the motors which in turn moves the leaves to achieve the required contour with 0.2mm efficiency.
All the communication established between the GUI & the controller is based on TCP/IP communication while that between the controller and the motor is based on

CAN (Controlled Area Network) communication module.
Keywords **–LabVIEW FPGA, Real Time system, Multi Leaf Collimator, Motors, Radiotherapy dosage, field shaping**

I. SYSTEM OVERVIEW

The rationale for using MLCs in conventional radiation oncology is to improve the efficiency of treatment delivery. Thus, the intent of this paper is to assist medical physicists, dosimetrists, and radiation oncologists with the acquisition, testing, commissioning, daily use, and quality assurance (QA) of MLCs in order to realize increased efficiency of utilization of therapy facilities.

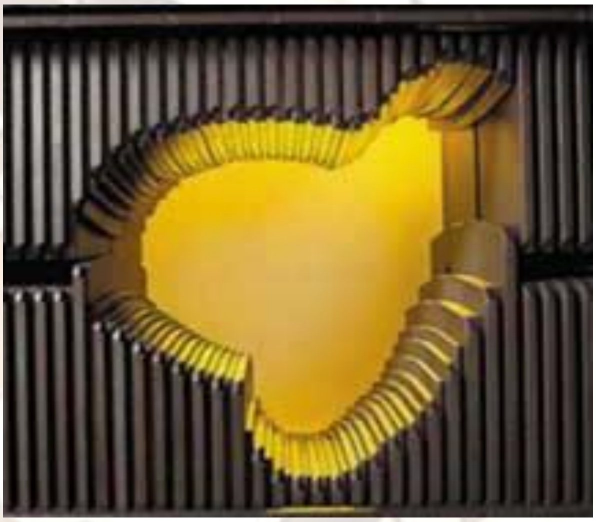

Fig.1 Schematic of field shaping of beam

A major limitation to the efficacy of radiotherapy treatment is the production of undesirable complications by the irradiation of healthy tissue inherent in a given radiotherapy technique. Many organs are relatively sensitive to radiation damage (the spinal cord, salivary glands, lungs, and the eyes are common examples) and must be given special consideration during radiotherapy treatment planning.
In general, treatment planners attempt to optimize the dose distributions achievable with a given treatment strategy to deliver a tumorcidal dose of radiation to the target cancerous cell while minimizing the amount of radiation absorbed in healthy tissue. Explicit field shaping of the beam (as shown in figure1) is required to reduce the amount of healthy tissue irradiated, and multiple beams are used to lower the dose absorbed by tissue outside the target volume.

A. *System Configuration* - MLC configuration is categorized as to whether they are total or partial replacements of the upper jaws, the lower jaws, or else are tertiary collimation configurations. The configuration described in this paper creates a number of x-ray beam collimation and control configurations. The tertiary block trays and the gantry housing are placed closer to the patient as shown in figure1.

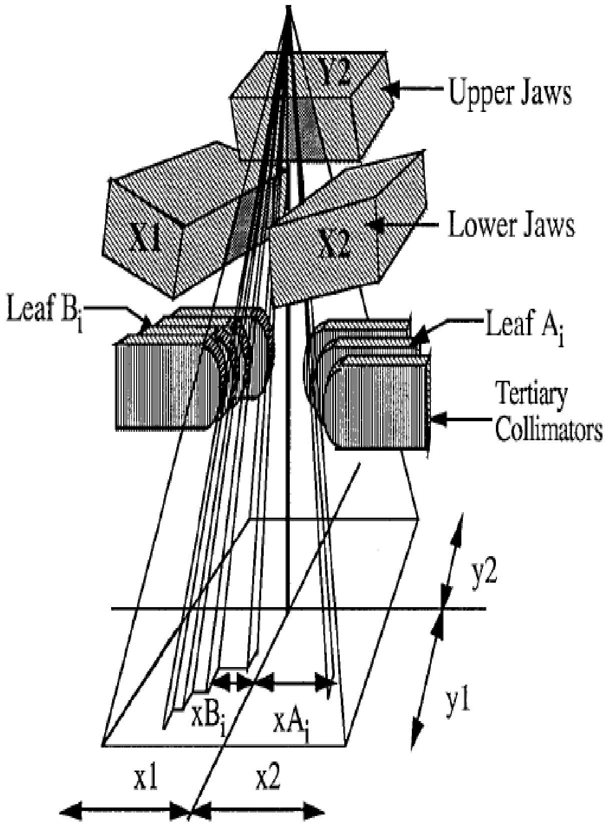

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Fig.2 Schematic of a photon collimation system with upper and lower jaws and a tertiary multi leaf collimator.

The figure below shows the design of the leaf. The *width* of the leaf is the small dimension of the leaf perpendicular to the direction of propagation of the x-ray beam and perpendicular to the direction of motion of the leaf.

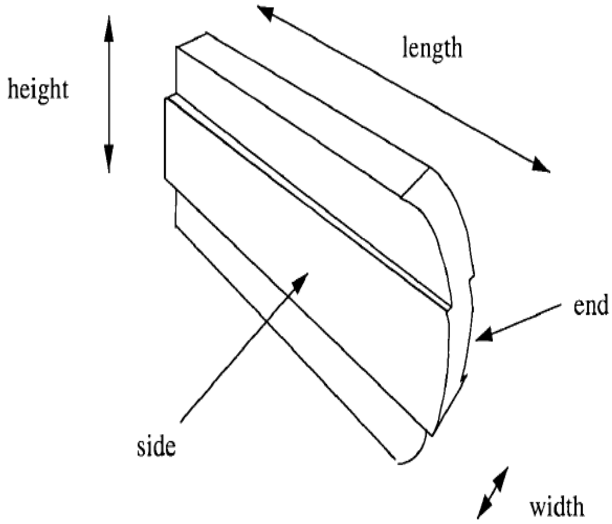

Fig.3 Schematic of generic MLC leaf illustrating leaf terminology. An example of a curved end and a stepped side

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II.TECHNICAL SPECIFICATIONS OF THE DESIGN

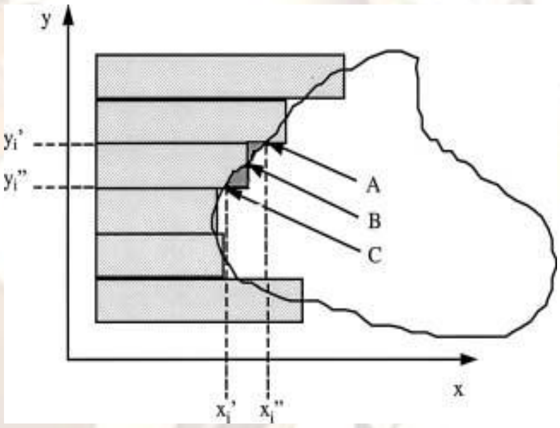

Fig.4 Demonstration of the "out-of-field"

The circumference or the outer diameter of the plate on which the MLC is fitted is 850 mm, while the radiation window through which the beam is passed has a dimension of 200 x 200 mm. There are two banks or carriage on the either side of radiation window which encapsulates 40 leaves on each side to achieve the required contour. These leaves are driven by 80 corresponding motors. These motors are controlled by the NI cRIO-9024 Real Time controller through CAN module of communication.

Figure 4 shows how the required contour is achieved using multi leaf collimator and the occurrence of out of field of the leaves.

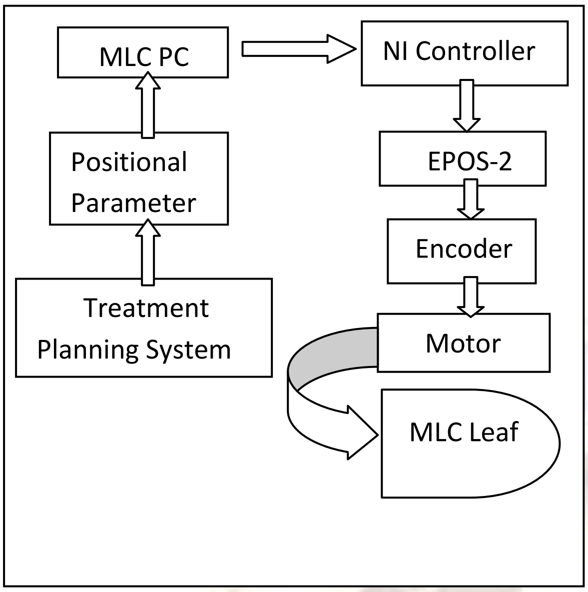

Fig.5 Block diagram of the proposed design

III. COMPACTRIO AND ITS HARDWARE MODULES

CompactRIO combines an embedded floating point processor (PowerPC) with real-time operating system VxWorks, a high-performance reconfigurable FPGA and hot swappable I/O modules within a single chassis. Hot-swappable I/O modules have build in conditioning, connectors and isolation for analog and digital I/O. Each I/O module is connected directly to the FPGA, providing low-level customization of timing and I/O signal processing. The FPGA is connected to the embedded real-time processor via a high speed PCI bus.

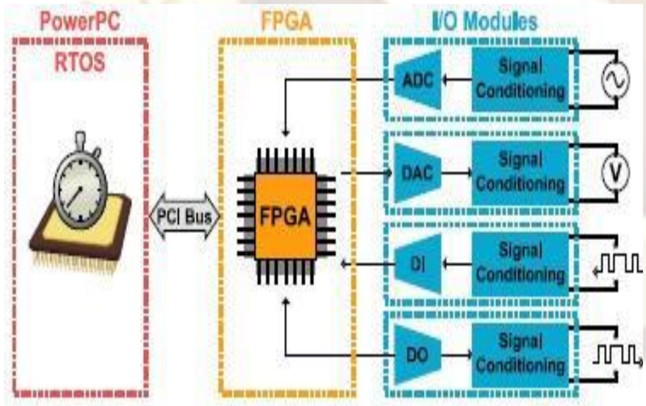

Fig.6 CompactRIO internal structure

CompactRIO 9025 real time controller is used which has 4 slots for C series I/O modules. The slots in the chassis are fitted in with a NI-9403 32 channel digital module, a NI-9205 32 channel analog module and NI-9853 CAN module.

Fig.7 NI CompactRIO 9014 Real Time Controller

The CompactRIO modular controllers and chassis have a wider temperature range -40°C to +70°C, a 4-slot option for a compact size, a higher performance reconfigurable FPGA, a full-speed USB port for adding additional storage with USB-based storage media and very low power consumption (approximately 8W)

IV. SOFTWARE MODULE DEVELOPMENT

For making the program at the target of NI CompactRIO, there two different VIs are designed:-

1) *LabVIEW FPGA VI:* The VI which is created under the FPGA target of the project explorer, designed on the platform of LabVIEW FPGA module and executes on the FPGA of CompactRIO device is called LabVIEW FPGA VI.

2) *LabVIEW Real-Time VI:* The VI which is created under the Real Time controller target of the project explorer, designed on the platform of LabVIEW Real Time module and executes on a dedicated processor running a real-time operating system is called LabVIEW Real Time VI.

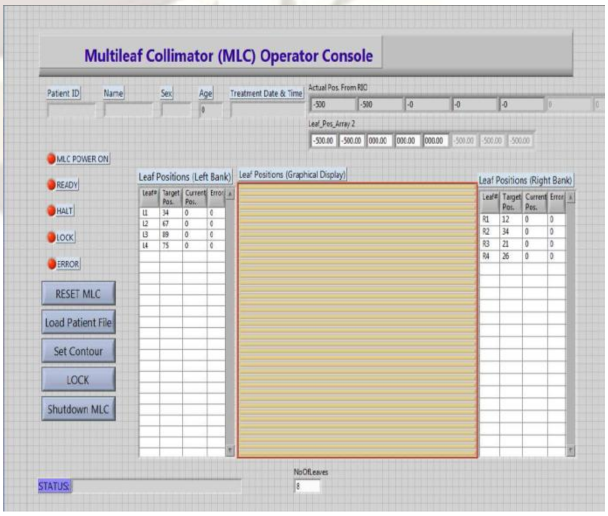

Fig.8 The user interface on MLC PC

Figure 8 shows the user interface available on the MLC PC. It basically include four basic commands namely-Emergency STOP or MLC shutdown, HALT, Read leaf position and Write leaf position(open/close window/set contour). All the commands mentioned here are in the order of their priority

The command frame format includes details such as: Task ID (1 byte), Task details (1 byte)
, Task Priority (1 byte), Data length (2 bytes), Leaf position array(320 bytes), Error code array(80 bytes). Out of the above mentioned details the leaf.

V. CONCLUSION & FUTURE SCOPE

Treatment of shaped portals by the use of an MLC is more efficient than by tray mounted blocks, especially when MLC field-shape files are saved and retrieved from an information management system. The efficiency gain has allowed the implementation of conformal therapy. In addition, computer-controlled MLC is used to implement various forms of dynamic therapy including intensity modulated conformal therapy

The proposed design of Multileaf collimator is a very useful clinical system for simple field shaping, but its use will get even more important in dynamic radiotherapy, with the leaves moving during irradiation. This enables a precise dose delivery on any part of a treated volume. Intensity modulated radiotherapy (IMRT), the therapy of the future, is based on the dynamic use of MLC.

ACKNOWLEDGEMENT

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REFERENCES

[1] http://www.ni.com
[2] LabVIEW FPGA Module user manual
[3] LabVIEW Real Time Module user manual
[4] LabVIEW FPGA module help
[5] Tarun K. Podder, Ivan Buzurovic, James Galvin & Yan Yu “Dynamics based decentralized control of robotic couch and Multi Leaf Collimators for tracking tumour motion”, IEEE International Conference on Robotics & Automation, CA, USA, May 19-23, 2008
[6] Operating instruction and specification NI 9403 32- channel, digital input/output module manual
[7] Operating instruction and specification CompactRIO 9012/9014real time controller manual
[8] Operating instruction and specification NI 9405-channel, analog output module manual