



Improved Image Quality for Tumor Surgeries

More and more hospitals are implementing image processing systems using multispectral cameras during surgery to visualize cancers. Quest Medical Imaging BV in the Netherlands offers such a system which has been expanded using a programmable frame grabber, including appropriate software from Silicon Software. Image preprocessing and processing take place on the FPGA processor, increasing data throughput and concurrently achieving the very low latencies needed for medical technology. Due to new image processing algorithms, image quality has been significantly improved for precise surgery.



Use of image processing technology in operating rooms/ Source: Quest Medical Imaging BV

With its Quest Spectrum platform, the company is developing an image processing system for hospitals that uses a proprietary developed multispectral camera. The resulting images, displayed on a monitor during the surgery, enable the surgeon to distinguish between a tumor and surrounding tissue during both invasive (open) and minimally in-

vasive laparoscopic surgeries. Prior to the surgery, a fluorescent marker is injected into the patient at targeted points; the marker then attaches to the tumor cells and is excited using NIR light. Markers differ depending upon the type of tumor. The multispectral camera concurrently records in high definition (HD) a color image in the RGB color space and two fluores-

cent images in the NIR spectral range. The color image and one of the NIR images are combined for image output.

The camera contains an RGB color sensor and two NIR sensors. It filters incident light via a spectral beam splitter beforehand into the five desired

frequency spectra (red, green, blue, and two spectra in the near infra-red range) along the same optical axis. In so doing, three congruent images for various spectral ranges are generated which can be aligned using color space conversion. The camera processes a data rate of 255 MB/sec at a maximum frame rate of 60 fps.



Live Images During Surgery

With the previous frame grabber-based image processing solution, the entire process from image acquisition via image pre-processing to image processing ran via the host PC's CPU. High-resolution camera recordings were forwarded directly to the CPU with no data reduction, reducing system speed. The microEnable 5 marathon VCL Camera Link frame grabber, newly integrated into the platform, now executes the entire process on the FPGA (Field Programmable Gate Array), without burdening the CPU and at higher speed. Using the processor, the images recorded using the multispectral camera are processed pixel-for-pixel with higher parallelism and two of the images are merged together for the result image.

With this new real-time solution, live images are displayed during the surgery for the surgeon, whereby s/he can identify the fluoresced tumor cells and better differentiate them from healthy

Quest Spectrum Platform with real-time result images/
Source: Quest Medical Imaging BV

tissue but also imaging lymph nodes and blood vessels (angiogenesis), something that is not possible with the naked eye. Instead of having to switch back and forth during surgery between black-and-white and color images, the surgeon has the option to choose between two alternative camera operating modes: either viewing the color and fluorescent images side by side or having both displayed together as a single, unified image. In so doing, the surgeon can better identify small tumors as well as control them with surgical devices. The frame grabber's performance is high enough to process both operating modes.

FPGA Algorithms With No Hardware Programming

One further important reason for this provider's selection was the frame grabber's programmability with the aid of the easy-to-use VisualApplets graphical programming environment. With this software, appropriate algorithms for image processing tasks can be generated as data flow diagrams, simulated, and implemented in very little time with no cumbersome or expensive VHDL programming by hardware specialists. "The project team, already well accustomed to FPGAs, tested the software independently using their own development environment, learned the handling with no special training, and integrated their own SDK within one to two weeks. Using the VisualApplets simulation function, they could generate realistic previews with no synthesis at any time and at any point in the application design, and promptly undertake corrections", reported Project Director Sander de Jonge, Engineering Manager at Quest Medical Imaging BV.

For the special image processing task, the team graphically programmed a hardware applet and loaded it onto the frame grabber's FPGA. The applet contains all the algorithms for image preprocessing such as shading correction, noise reduction, DeBayering color reconstruction, color correction, color

space conversion and artefact reduction in RGB and NIR images. Moreover, it uses tone mapping for image output to represent three sharp contrast images and regulates the combination of two synchronized color and NIR images into one resulting image with a green overlay for the surgeon.

One particular advantage of image preprocessing is the data reduction even before transfer to the evaluation computer, so that no bandwidth or storage space problems arise. Because of the FPGA's high performance and parallelism, cumbersome computations such as color conversions can be accelerated. Preprocessing parallel to image acquisition enables a very high frame rate, spares the host computer processing and usually allows more cost-effective system configuration. Data volumes thus reduced could be processed using a Camera Link frame grabber with BASE instead of FULL configuration, reducing the cost of the entire system.

Switching over to the new systems took place within a mere two months and was implemented by the project team with no significant manufacturer support. Following a short training period, they graphically programmed the necessary applications as a hardware applet. "The hard- and software can be implemented for any markers and thus for any type of tumor. It merely requires slight modification for any tumor type, for example, in relation to the required color spectra", de Jonge explained. "Our requirements were all implemented,



**Multispectral camera for high definition image acquisition/
Source: Quest Medical Imaging BV**

especially the real-time processing with the most minimal latencies, relieving the CPU, and better image quality for the surgeon. The time to market has been markedly reduced by virtue of the short implementation time.”

The entire system is superbly modifiable for future requirements, such as new cameras, camera interfaces, or expanded software functionalities. Using its simulation function, expansions along the entire image processing chain can easily be tested. First, further system optimization is planned. Switching to a higher performance camera interface, such as CoaXPress, is conceivable at a later date.

microEnable 5 marathon VCL: PCIe image processing device that allows the connection of two cameras of any Camera Link standard specification.

- ◆ All formats of Camera Link standard including non-Standard formats
- ◆ Support of long cable length
- ◆ Onboard image preprocessing functions
- ◆ Industrial multi-device, multi-camera support
- ◆ DMA 1800 / up to 1800 MB/s PCIe Data bandwidth (PCIe x4 Gen2)
- ◆ Supports opto-decoupled signals via front I/O
- ◆ Broad support of Third-party software interfaces
- ◆ Versatile application and industry usage
- ◆ Custom FPGA programming with VisualApplets supporting Xilinx Kintex FPGAs
- ◆ PoCL SafePower



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