Colour space transformation, colour correction and exact colour reproduction on FALCON architecture

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Nowadays many problems requiring huge computing power have risen. Although the performance of digital processors doubles yearly, there are certain tasks where the computation cannot be carried out within a reasonable time interval. Such hard problems are the analysis of big dynamical systems or real-time exact colour reproduction. The exact colour visualization of motion pictures is necessary in industrial, medical and scientific research areas. Thus, for example, exact colour reproduction is required for remote medical diagnosis or remote operation. The doctor has to see the same image that appears in reality. Device dependent colour appearance may cause faulty decisions. Nowadays these problems cannot be solved perfectly because many steps of the transformation are not completely known and the huge number of computations cannot be done in real-time even by the fastest PC. In this article is described some methods to produce exact colours in a remote medical diagnostic system.

Recently, the requirements towards remote medical diagnostic systems have changed significantly. The diagnosis based on verbal information is not satisfactory. The communication between the doctor and the patient can be realized in video conferencing system. In some cases it could be a very important point of view of the exact diagnosis that the skin of the patient be displayed on the screen in the same colour as it is in reality. Serious scientific and technological apparatus is required to realize this kind of system. There are two fundamental points of view relating to this type of system. First the main characteristics of the output of the imaging medical systems have to be examined. For example, it is a very important task for the output images of CT (Computer Tomograph) and MRI (Magnetic Resonant Imager) where a minimal deviation is a very important point of view of the diagnosis. On the other hand, the exact colour reproduction in remote medical diagnostic systems has to be assured. Some environmental parameters have to be fixed to realize the exact colour reproduction, for instance the minimal resolution and colour depth of the monitor or the camera or the direction and the luminance of lighting. The real-time processing of motion pictures has a huge claim to computing power. The fastest computer is the ASCI White supercomputer implemented by IBM in 2001 consisting of 8192 processors with 7.226 TFLOPS computing power [1]. In many image processing applications this huge computation power is really needed, the operations are special and do not require the 32 bit floating point accuracy. One alternative is the analogic CNN array computer performing about Tera-equivalent operations per second, on a single chip. The latest analogue CNN chip has a resolution of 128×128 pixels and its equivalent computing power is 4 Tera-equivalent operations per second but its computational precision is about 7 or 8 bits [2]. We need an accuracy of at least 12 bits and higher computing performance than in software simulation, so hardware acceleration is required. The Falcon emulated digital CNN-UM chip is used to speed up our computations. [3] Falcon is a configurable architecture where the neighbourhood value of the templates, the accuracy of the state and template values and the size of the emulated cell array can be changed. The architecture utilizes the flexibility of the FPGAs (Field Programmable Gate Array) that makes it possible to try several configurations on the same hardware and choose the architecture that is the best for our application. In our case the multi-layer extension of the Falcon architecture called Falcon-ML, especially the three-layer case, was extensively used where each colour component had a separate layer. Using the Falcon architecture 20 to 150 fold speedup can be achieved compared to the software simulation; this makes real time colour space transformation, colour correction and exact colour reproduction possible even in the highest resolution.

References

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[3] Zoltán Nagy, "Configurable multi-layer CNN-UM emulator on FPGA", to be published on CNNA 2002, Frankfurt, 2002