Parallel Computational issues in Medical Imaging

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In nuclear medicine Single Photon Emission Computed Tomography (SPECT) is a diagnostic technique which aims at the determination of the spatial distribution of radiopharmaceuticals injected into the patient's body or inhaled. A detailed knowledge of such a distribution can give functional information useful for the physician, since it can supply some kind of monitoring about factors as blood flow rate, metabolic processes and so on.

Many physical effects intervene during a SPECT acquisition process, usually with the result of a deterioration of the collected information. Scatter, attenuation, noise and collimator blur are the most relevant ones.

In the case of parallel collimation (the case considered in this study), a general formulation of the SPECT acquisition process can be expressed in terms of the class of the so-called "3D blurred Radon transforms". Three choices for the kernel $F(s,z,t)$, corresponding to three different models of SPECT data acquisition, are presented, namely the kernel of the fully 3D model

$$F_{3D}(s,z,t) = \frac{1}{2\pi\sigma^2(t)} \exp\left[-\frac{s^2+z^2}{2\sigma^2(t)}\right], \tag{1}$$

the kernel of the 2D model

$$F_{2D}(s,z,t) = \frac{1}{\sigma(t)\sqrt{2\pi}} \exp\left[-\frac{s^2}{2\sigma^2(t)}\right] \delta(z) \tag{2}$$

and, last, the kernel of the 2D+1 model [2]

$$F_{2D+1}(s,z,t) = \frac{1}{\sigma(t)\sqrt{2\pi}} \exp\left[-\frac{s^2}{2\sigma^2(t)}\right] \frac{1}{\sigma_{av}\sqrt{2\pi}} \exp\left[-\frac{z^2}{2{\sigma_{av}}^2}\right], \quad (3)$$

which is proposed as the intermediate between the previous two.

Numerical restoration of SPECT data, is performed by means of iterative methods applied to a discretized version of the problem stated above (FBP, CG, EM).

Concerning the performances in terms of accuracy and timing requirements, in the fully 3D model gives the most accurate reconstructions in a time which is considered too long for the clinical setting whereas the 2D and 2D+1 approaches have timing requirements which are one order of magnitude smaller and, consequently, can be accepted there. The accuracy performance of the 2D model is not quite satisfactory while the reconstructions generated by means of the proposed 2D+1 model compete in accuracy with the ones of the fully 3D approach.

In this work we describe the parallel software which has been developed for restoration of 3D and 2D+1 SPECT data. Numerical experiments aimed at evaluate parallel performance of the parallelization strategies have been carried out on a syntetic test case, using a MIMD-DM machine, i.e. a Beowulf System with 32 Pentium II nodes connected by a switch with a peak bidirectional bandwidth of 100 Mb/s.

First results show a reduction of the execution time of the 2D+1 restoration of at least 97 percent. The execution time reduces from about 9986 secs (less than 3 hours) with one processor to 315 secs (about five minutes) using 32 processors, a response time acceptable in a clinical environment.

References

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[2] **P. Boccacci - P. Bonetto - P. Calvini - A.R. Formiconi**, *A simple model for the efficient correction of collimator blur in 3D SPECT imaging*, Inverse Problems, 15, 1999, pp. 907–930.