

Re-gridding CT-data using Hermitian polynomial curve interpolation

W. Volken¹, D. Frei¹, P. Manser¹, R. Mini¹, E.J. Born¹, M.K. Fix¹

¹Division of Medical Radiation Physics, Inselspital and University Bern
mail: michael.fix@ams.unibe.ch

Introduction

Re-gridding of data distributed in a spatially grid to finer or coarser resolution is a fundamental task in the field of data processing. The gridding process requires a re-distribution of the original dataset to a user requested grid according to a distribution function, which can be determined on the basis of the given data by interpolation methods. Commonly used interpolation methods are piecewise linear, cubic or higher order polynomial interpolation functions. However, these interpolation functions can result in unrealistic values for the re-gridded dataset. The gridding-algorithm presented in this work was developed in order to overcome these problems.

Material and Methods

Any re-gridding process can be separated into two steps: First, because the originally given data has to be redistributed to a different grid, a distribution function has to be determined from the given data. Second, the source data is re-distributed to the desired grid using this distribution function. A gridding-algorithm suitable for re-binning histogrammed data should have the following features:

- Global and local integral conservation.
- No negative interpolation values of positively defined quantities.
- Ability to control re-gridding artifacts like overshoots and undershoots.

In general, these conditions are not met by the commonly used linear, cubic or higher order polynomial interpolation methods, which may re-grid the source data in an unphysical way. The gridding-algorithm developed in this work is based on Hermitian polynomial curve interpolation (HCI) and is designed to fulfill the above listed features [1].

The HCI algorithm is compared with gridding-algorithms using linear and cubic interpolation functions on a dataset with a very irregular grid combined with highly varying data and on series of X-ray CT-images (head and neck, lung, pelvis). Thereby an image quality index has been used to quantify the quality of the interpolation method [2]. This index is a product of three components: The first component is the linear correlation coefficient between the original dataset and the sampled dataset. The second component measures how close the local mean values are. The third component measures how similar the local variances of the datasets are. The quality index has a dynamic range of $[-1, 1]$, where the best value 1 is achieved if and only if the two datasets are identical.

Results

Re-gridding of the dataset with the irregular grid using linear and cubic interpolation show that such interpolation functions may over- or underestimate the source data by about 10% to 20%, while the HCI algorithm can be tuned to significantly reduce these interpolation errors. When the HCI algorithm is applied on series of X-ray CT-images, the accuracy of the sampled images is significantly improved: Going from the linear interpolation algorithm to the cubic interpolation algorithm improves the quality index by about 5-10% and going from the cubic algorithm to the HCI algorithm leads to a further improvement of 10% in terms of the quality index.

Discussion

Inaccurate values may occur in a re-gridding process due to the lack of integral conservation. Re-gridding algorithms using high order polynomial interpolation functions may result in significant artifacts of the re-gridded data. Such artifacts can be avoided by using the HCI algorithm. This work was supported in part by Varian Medical Systems.

References

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- [2] Wang, Z.; Bovik, A.C.: A universal image quality index. IEEE Sig Process Lett. Vol. 9, 2002, pp. 81-84