Effects of Uneven Sampling in 3D Reconstructions.

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The specialized literature [1,2] has raised several concerns related to the behaviour of 3D reconstruction methods when the projection directions are not evenly distributed. It seems that if certain projection directions are privileged (more common) than the rest, 3D reconstruction algorithms tend to elongate the reconstructed volume along those directions.

We present a comparison between the behaviour of different well-known 3D reconstruction algorithms as applied to macromolecular structural studies: weighted backprojection (WBP), simultaneous iterative reconstruction techniques (SIRT) and algebraic reconstruction techniques (ART with blobs), as implemented in [3], [4] and [5], respectively. The conclusion we reach is that ART introduce less artifacts than the other two proposed methods.

1. RESULTS ON REAL DATA

For our comparison of the performance of WBP, SIRT and ART using a real case, the giant hemoglobin of *Lumbricus terrestris* [6] was chosen as test specimen. 3099 projections of 90×90 pixels were obtained without tilting the specimen support. The angular distribution of the projections is shown in fig. 1. The results, summarized in fig. 2, strongly suggest that ART outperform the other two reconstruction methods.

2. DISCUSSION

The reason for the distortions along overabundant projection directions is related to the fact that some reconstruction algorithms give a higher weight to the oversampled regions. ART does not seem to suffer from such distortions because it deals with one projection at a time. In each step, first an experimentally obtained projection is selected, then the corresponding projection is computed from a "trial volume", this computed projection is then compared with the experimental projection, and finally the trial volume is updated to reduce the difference between the computed projection and the experimental one. As opposed to this, both WBP and SIRT deal with all the projections simultaneously in their respective processes toward producing a reconstruction.

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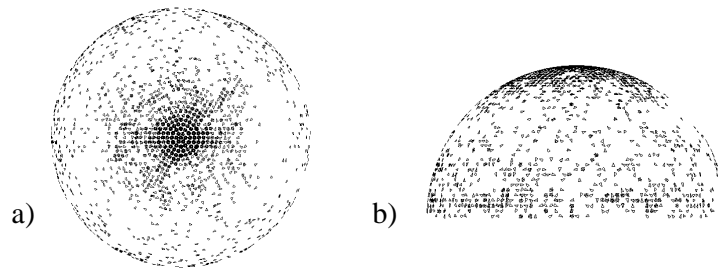
a)   b)

Fig.1: 3D map of the eulerian angles. The object being fixed at the centre of a sphere, the directions of projection correspond to rays originating from the object and leaving a mark when intersecting the sphere. The map (restricted here to a half-sphere) is seen from the top (a), and from the side (b). The oversampled projection directions are revealed by numerous marks near the top of the half-sphere.
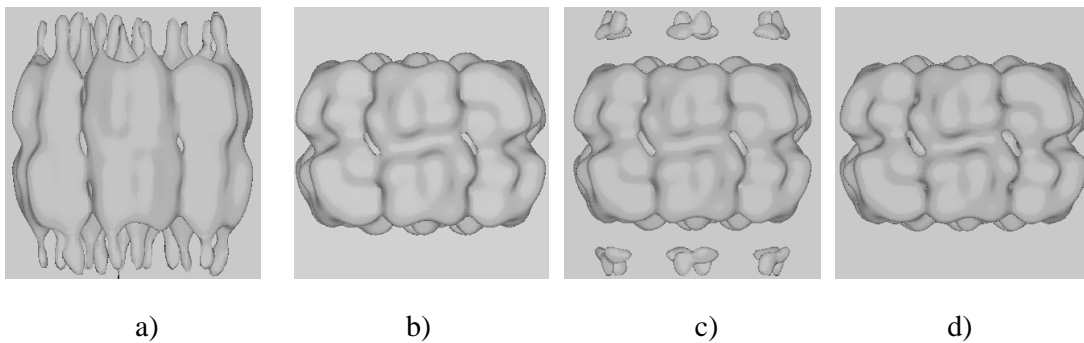

a)   b)   c)   d)

Fig 2: Three dimensional reconstruction (side views) of the *Lumbricus terrestris* extracellular hemoglobin performed using (a) SIRT, (b) ART, (c) WBP, all of them from an unevenly distributed set of projections defined in fig.1, (d) the same as (a) after removing overabundant projections (for this case the results obtained with the 3 methods are quite similar, here only those for SIRT are shown).