New reconstruction algorithms for the improvement of SMOS L1c images: preliminary results

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To avoid introducing additional artifacts, all the Fourier series were calculated on the hexagonal grids, using isometries with $\mathbb{Z}_n$

$$e^{2\pi i \vec{x} \cdot \vec{k}/N} = e^{2\pi i \Phi(\vec{x})\Psi(\vec{k})/N}$$

where $\vec{x} \in \mathbb{H}(n)$ ; $\vec{k} \in \mathbb{H}^*(n)$

and

$$\Phi : \mathbb{H}(n) \rightarrow \mathbb{Z}_N$$
$$\Phi(x, y) = x + y(3n^2 - 1) \pmod{N}$$

$$\Psi : \mathbb{H}^*(n) \rightarrow \mathbb{Z}_N$$
$$\Psi(k, l) = nk - l(n + 1) \pmod{N}$$

And the total number of points is $N = 3n^2 + 3n + 1$
In the case of SMOS, visibilities are computed on a star-shaped subsampling in Fourier space (radius: 42).
This leads to characteristic “star-like” tails that affect all the image.
And what happens if we remove the tails by taking the central hexagon? (radius=21)
Tails are somehow attenuated, but not removed.

Tails do not only come from lost high-frequency Fourier coefficients.
The origin of tails

Tails come from having a delta function at a resolution higher than the one resolved by our representation (radius=126, truncation=42)
Nodal points

What happens if we increase the size of the embedding hexagon (42, 84, 126...)?
We thus increase the nominal resolution in direct space, and the oscillating structure of tails becomes more and more evident.

Nodal points are evident (not fused)
Nodal sampling: why?

- **Nominal sampling**: What we do by default.
  - Each pixel has nominal size
  - Adequate if high frequencies are negligible
  - Appropriate for smooth functions

- **Nodal sampling**: Subsampling of given points at higher resolution
  - Each pixel has smaller size (that of higher res.)
  - Adequate if the signal is a mixture of sharp transitions + a continuous signal (low contribution at high frequencies)
  - Appropriate for extracting the smooth component if it varies slowly in space
Nodal sampling: ideal case

Window: star (size=42)
Deltas: size=42
Embedding: size=255

Result: minima form an almost regular grid of spacing $\approx 6 \approx 255/42$
Ideal sampling: results

Hexagonal cut = 21
Size = 126
Centered grid with spacing = 6

No real improvement
Constant shift on the grid

Hexagonal cut=21
Size=126
Grid of spacing=6 displaced by (2,1)
Min signal

Significant improvement
**Adaptive grid**

Hexagonal cut = 21
Size = 126
Grid of spacing = 6
Local shift \(\leq 1\)
Max grad
Min acc. TB

Sampling: 62%
Huge quality improvement
Adaptive grid (2)

Star cut = 42
Size = 126
Grid of spacing = 6
Local shift <= 2
Max grad
Min acc. TB

Sampling: 62%
Huge quality improvement
Work in progress

- Extensive testing with synthetic images, algorithm improvements, etc
- Fusing non-uniformly sampled TB’s with SST to produce uniformly, densely sampled TB’s

TH at 34° incidence angle
Data presently in CP34-BEC

http://cp34-bec.cmima.csic.es
Next plenary meeting foreseen in October 2013

Additional institutions and countries are welcome!
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