curvelet_model_notes

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1 Curvelet Model: Notes

1.1 Formulation of the model

1. This corresponds to the physical fact that the distribution of the stellar mass is concentrated at a few clusters with similar age and metallicity.

Rather than age metalicity *clusters*, I would say that mass is concentrated on a few distinct *tracks* in age metallicty.

2. One can normalize the LOSVD by estimating first the line-of-sight velocity of the galaxy (is this the average velocity of all stellar populations, or something else?), and then shift the LOSVD by this amount

The line-of-sight velocity of the galaxy would be the mean of the LOSVD. In practice, we don't know this a-priori (hence the need for this model) and therefore normalise by a crude estiamte of the galaxy's line-of-sight velocity. This means that we can assume the LOSVD is *roughly*, though not exactly, centered around zero.

3. equation 1.3, typo? $\theta \to \theta_v$

4. number of wavelet bins number of wavelength bins

5. note, M_total is unknown (i.e. the normalisation of f is unknown) - I added it to demonstrate that SSP models have units of mass per wavelength.

1.2 Discretization of the distribution function

1. any intution for the parameters (a, b)?

2. $\mathbf{i} = (j, k, l) \in I_c$ i.e. is a 3D indexing over the curvelet parameters i.e.

3. Note that we have only a finite number of wavelength bins so that our measurement is actually m- dimensional, where m is the number of bins. Thus, we need no additional discretization of the measurements.

What's the context for this sentence? Are there cases of infinite-dimensional measurements…? Or, under what circumstances would you need to additionally discretize the data?

1.3 3. The computational approach

1. Since any sampling-based approach to uncertainty quantification is likely to be computationally infeasible,

Is this true…!? Especially if we use curvelets…?

2. Mode-based covariance estimation for unconstrained maximum-a-posteriori inference is well-known and widely-used. If $\mathbf{x}^*$ is a MAP estimator for the statistical inverse problem…

   then the posterior covariance Σ_{post} can be approximated by …

What about constraints!? Does this approximation of the posterior covariance account for constraints!? Is it a problem if not…?

These estimates can be generalized to the constrained case as in [5].

Ah. Ok. What's the rough idea…? Another transformation…?

1.4 4. What remains to be done

Prior hyperparameters

Simple enough for the LOSVD parameters. Need some intuition, understanding for the curvelets.

5. Curvelet transform and optimization method Curvelet transform and optimization method: There is already a good implementation of the fast curvelet transform in CurveLab (www.curvelet.org/software), which is freely available for non- commercial use. For the CGN method, I know some people that I could mail for code, but it will probably be easier in the long run if we implement it by ourselves.

Any down-side (other than time, potentially?) to re-writing?

1.4.1 Open questions

6. How does the discretization of the measurement P_{N_y} look like…? Is it accurate to write the discretized measurement as … where I_j is the j-th wavelength bin…?

No… it's a convolution. Give derivation of log transformed? See docstring of convolve_integrate_transform. How did you implement it? Convolution using FFTs.

7. As an alternative to curvelets, we could also use a Gaussian mixture model … So, Gaussian mixtures could also be a viable alternative. But this hinges of course on the following question: Is the distribution function of a galaxy well-modelled by a mixture of Gaussians?

No. Probably not. But, we can provide phycially well motivated, parameterised analytic models as alternatives.

1.4.2 Wishlist

8. Observation operator: An implementation of the input-output operator G given by (1.4). Ideally an implemented function that takes f and v as input and returns the corresponding measurement $\bar{y}$. It would be helpful if this part is well-documented, so that we can adapt it quickly to the curvelet formulation.

Already there, more or less. I can packaage it up into a single, well-documented function for your usage…

9. Fake data simulator Ideally, the program would randomly generate realizations of f that look (at least approximately) like distribution functions of real galaxies.

Also easy enough if we use Ryan's chemical evolution model. But, we should still think whether to also consider this as (an option?) for the generative model.

10. Access to the Monte Carlo implementation:

Also no problem, I can briefly describe the Monte Carlo implementation. Need to be sure if we are comparing like-for-like, however. Currently it is implemented a "finite difference prior" i.e. very different from curvelets. Using Ryan's chemical evolution model could make things more directly comparable.

11. Priority list for the wishlist? I assume operator, simulator, Monte Carlo implementation.

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