Modeling and robust estimation of a series of point sources in multidimensional imaging

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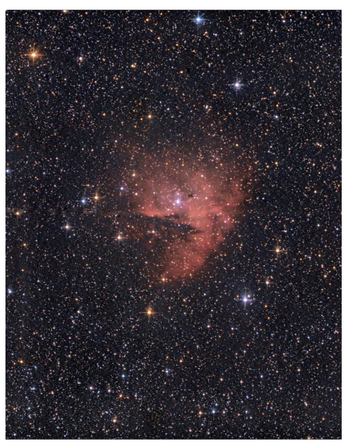
1. Introduction

Detection and extraction of stellar objects (**point light sources**) from astronomical images

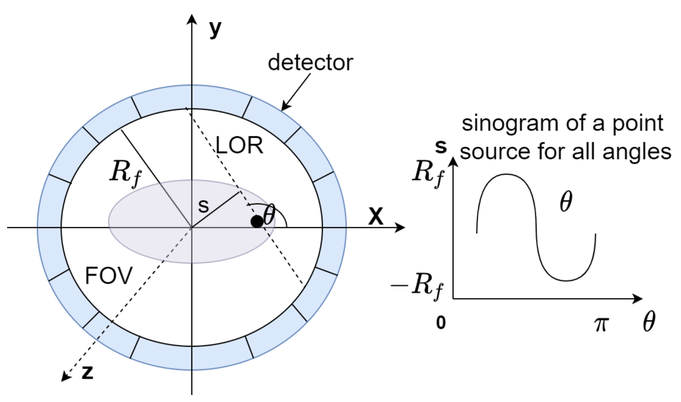
- stellar objects - blurred and extended in the image plane due to different image degradations
- the joint action of all those degradations can be approximated by **2D Gaussian profiles** very well

Low-dose 2D PET imaging

- implies the reduced amount of injected radiotracer into the patient's body, low signal-to-noise ratio (SNR), **sparse sinogram**, and **low quality** of the reconstructed image



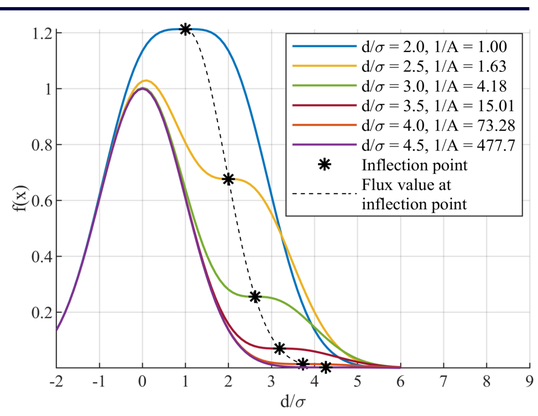
Astrophotography



2D PET imaging

2. Problem Description

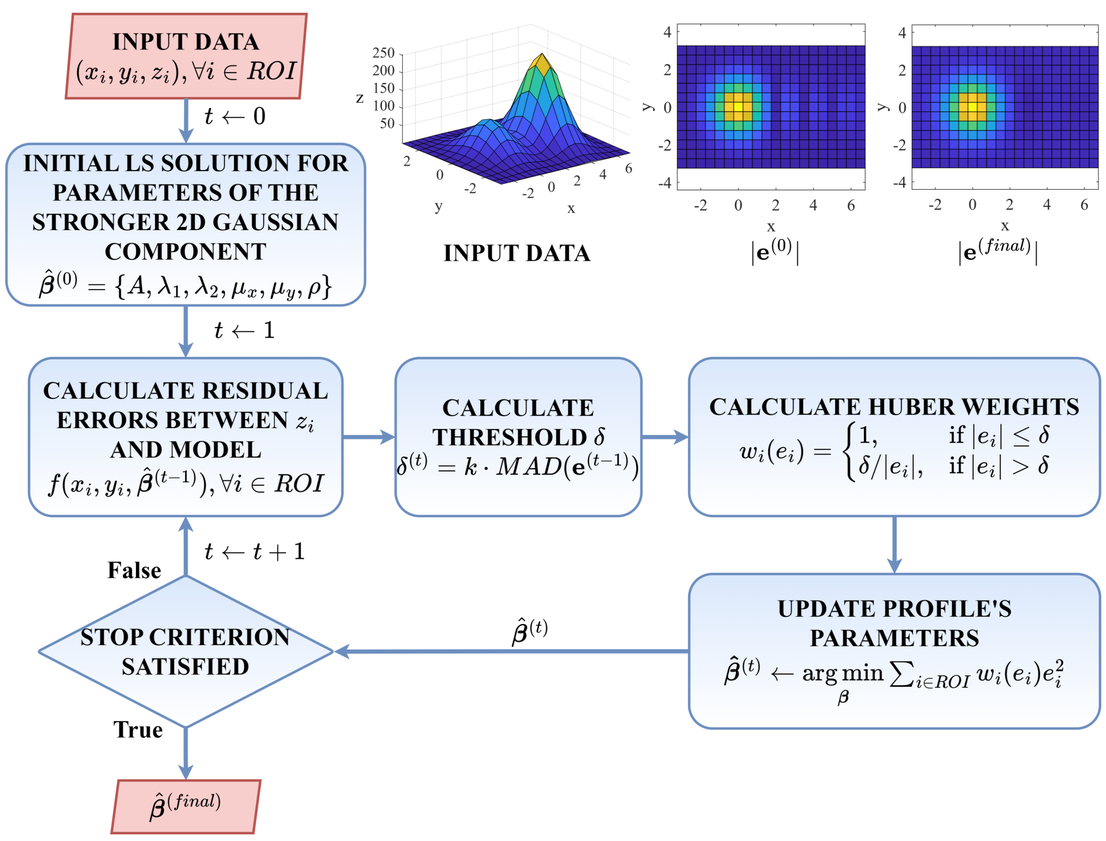
- Detect and extract the **overlapped** stellar components from noisy measurements even **above the resolution limit**
- **Multidimensional** Gaussian profile fitting
- Image reconstruction of the unknown underlying process in **low-dose** 2D PET imaging



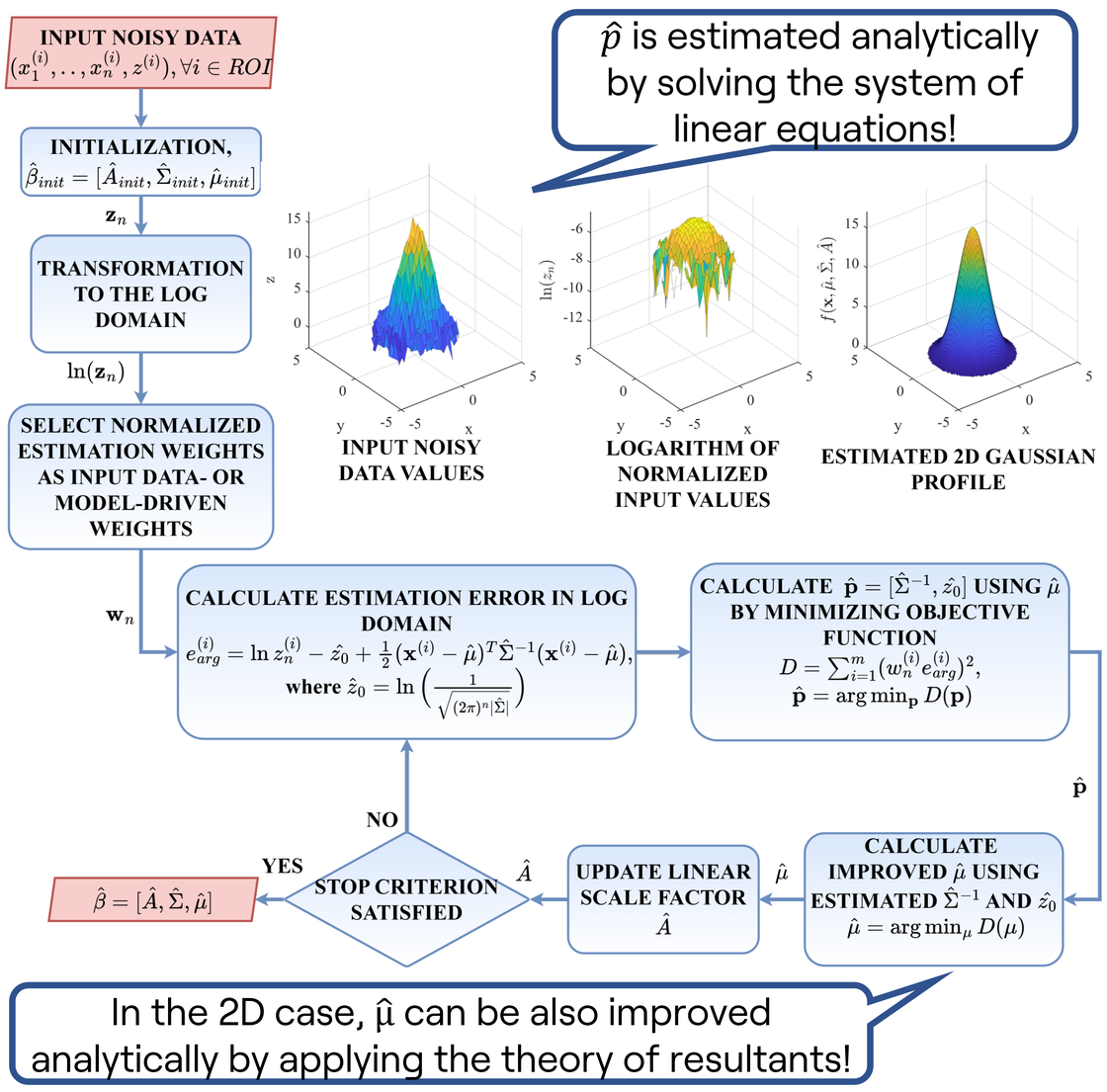
Sums of two 1D Gaussian profiles with parameters $\sigma = 1, \mu_1 = 0, \mu_2 = d$

3. Methodology

- **Iteratively reweighted least squares (IRWLS) method** for precise detection and extraction of the overlapped 2D Gaussian profiles based on **robust statistics**



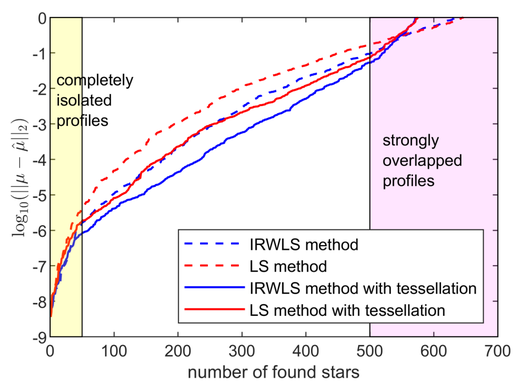
- **Fast two-step method** for fitting a multidimensional Gaussian function **in the log domain**



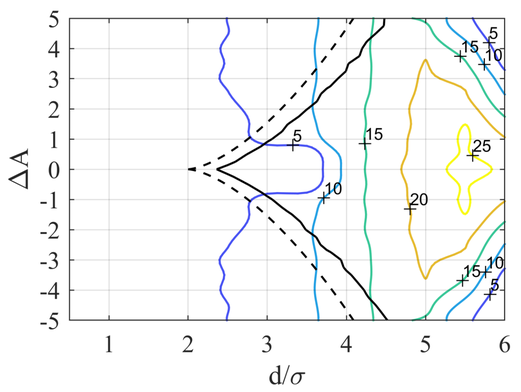
- 2D PET image reconstruction by using the **intersections of response lines** generated by unknown underlying process

4. Results

- IRWLS method results

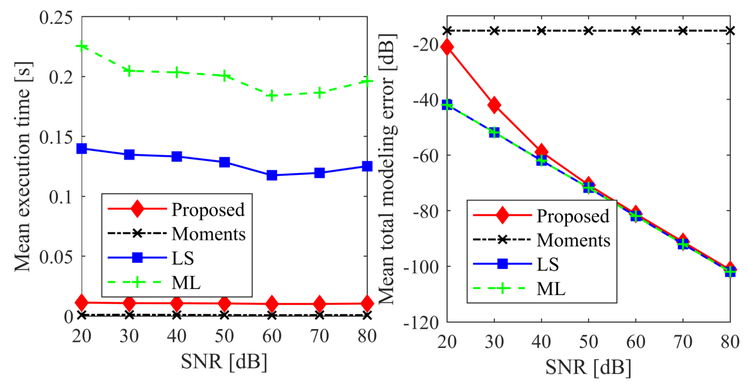


Sorted log10-distances of estimated and actual centroids



IRWLS method modeling gain in dB compared to the LS method

- Fast method for multidimensional Gaussian fitting (m = 7000)



5. Conclusion

By using the proposed IRWLS method, it is possible to precisely estimate overlapped 2D Gaussian components even above the resolution limit. For a given centroid position, the proposed fast method in the exponential's argument domain yields the one-step solution for all other parameters of the multidimensional Gaussian profile with high accuracy.

6. Project Acknowledgement

This work was supported in part by the Croatian Science Foundation under Project IP-2019-04-6703 and DOK-01-2018 and in part by the European Regional Development Fund under Grant KK.01.1.1.01.0009 (DATACROSS).