ASTRONOMICAL IMAGE PROCESSING

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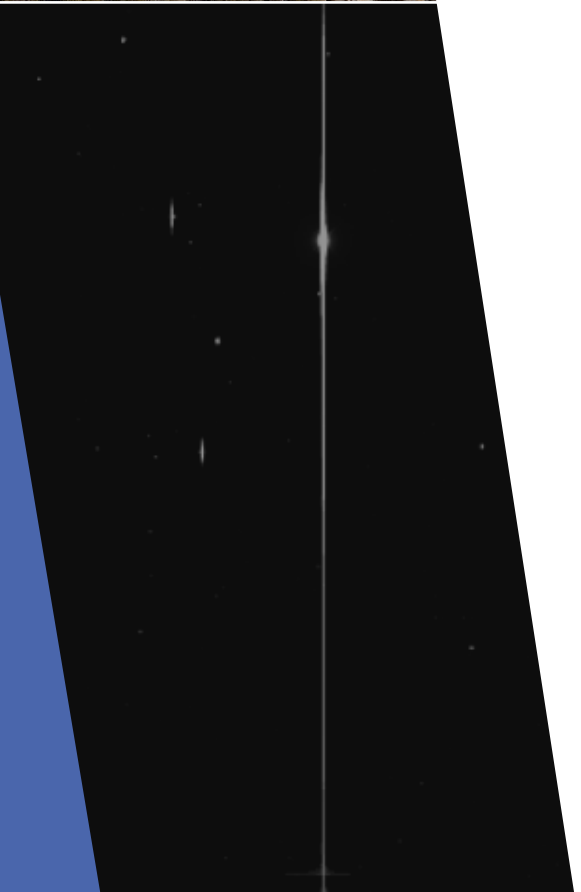
Contents

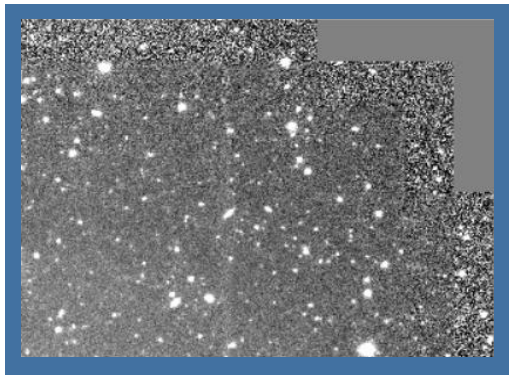


Background

- Analyzed a deep optical image of an extragalactic field, taken as part of the SWIRE infrared survey.
- Image produced using CCD detector.
- Goal of experiment is to determine the number of extragalactic objects.
- Assuming even distribution of galaxies, plot of magnitude vs log of cumulative number of galaxies below that magnitude:

$$\log N(m) = 0.6m + constant$$

Image Processing



Removed noise at borders and corner errors from image.

Subtracted the local background from different regions in the image, due to varying background brightness in the image.

Identified a cutoff brightness that occurred at center of blooming objects.

Removed blooming objects by connected component analysis.

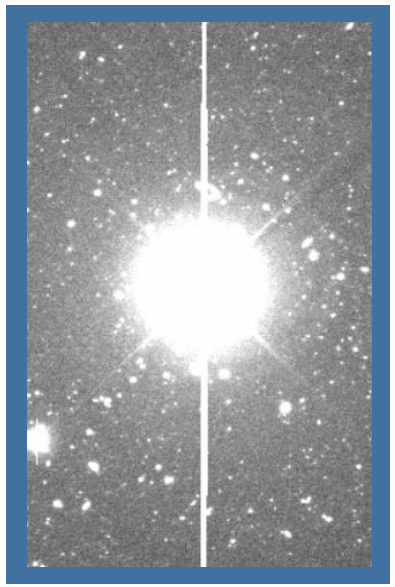


Image Processing Continued…

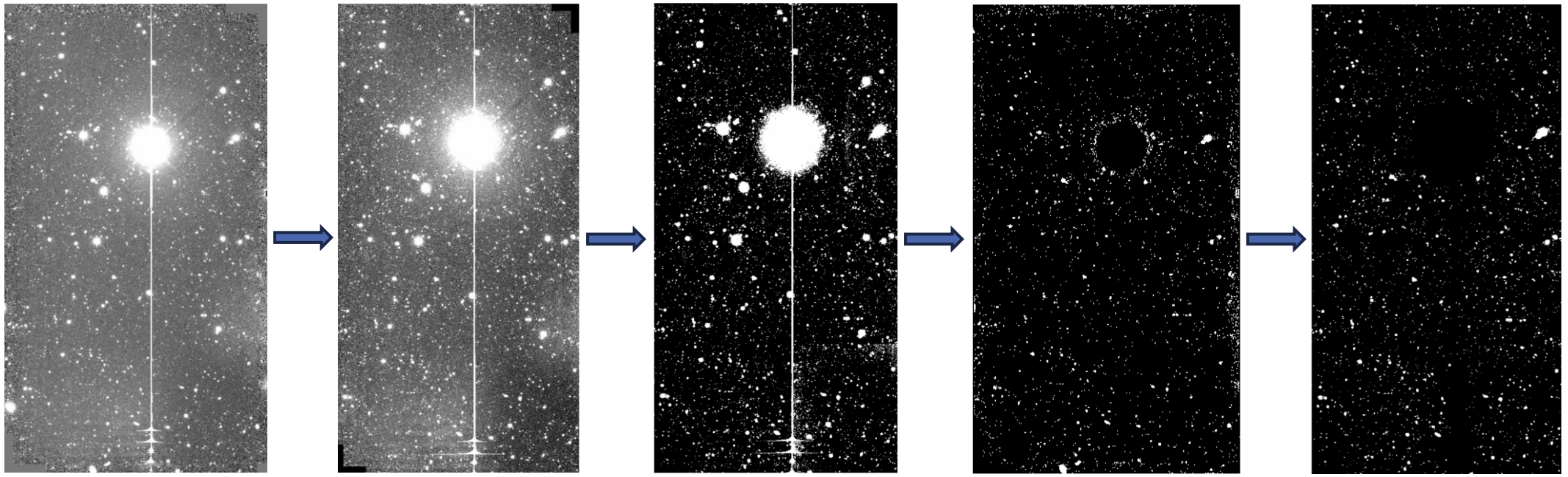
Image still contained pixel sized specs from background variation and leftovers of blooming objects.

Used a 1px morphological opening to remove any specs.

Identified a threshold brightness which indicated that the pixel was part of an object.

Created a binary image, where all pixels that exceeded the threshold brightness were set to 1.

Image Processing Steps



Original Image

Cropped Edges

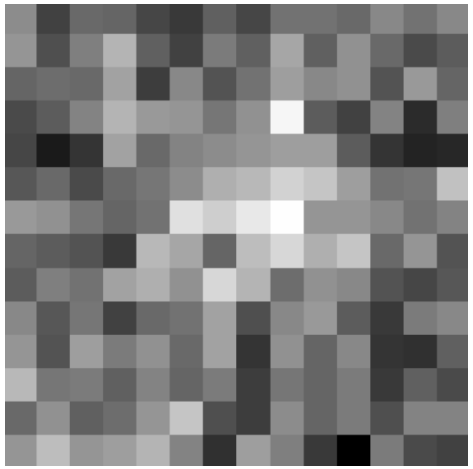
Subtracted Background

Removed Blooming Objects

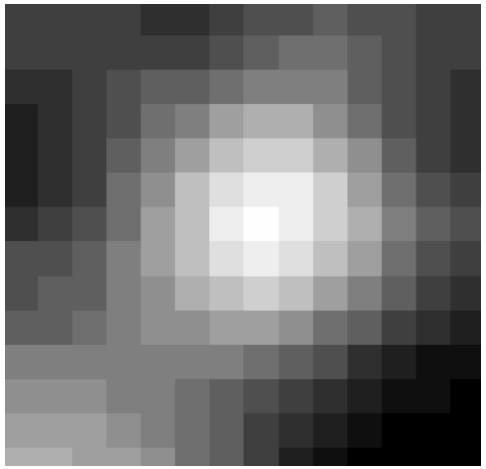
Binary Image

Extracting and Filtering Objects

- Connected component analysis used to extract objects from binary image.
- Added a 6px buffer around the extracted objects.
- Gaussian blur applied to objects to reject objects with multiple peaks.
- Reduced number of objects from 4979 to 1988.



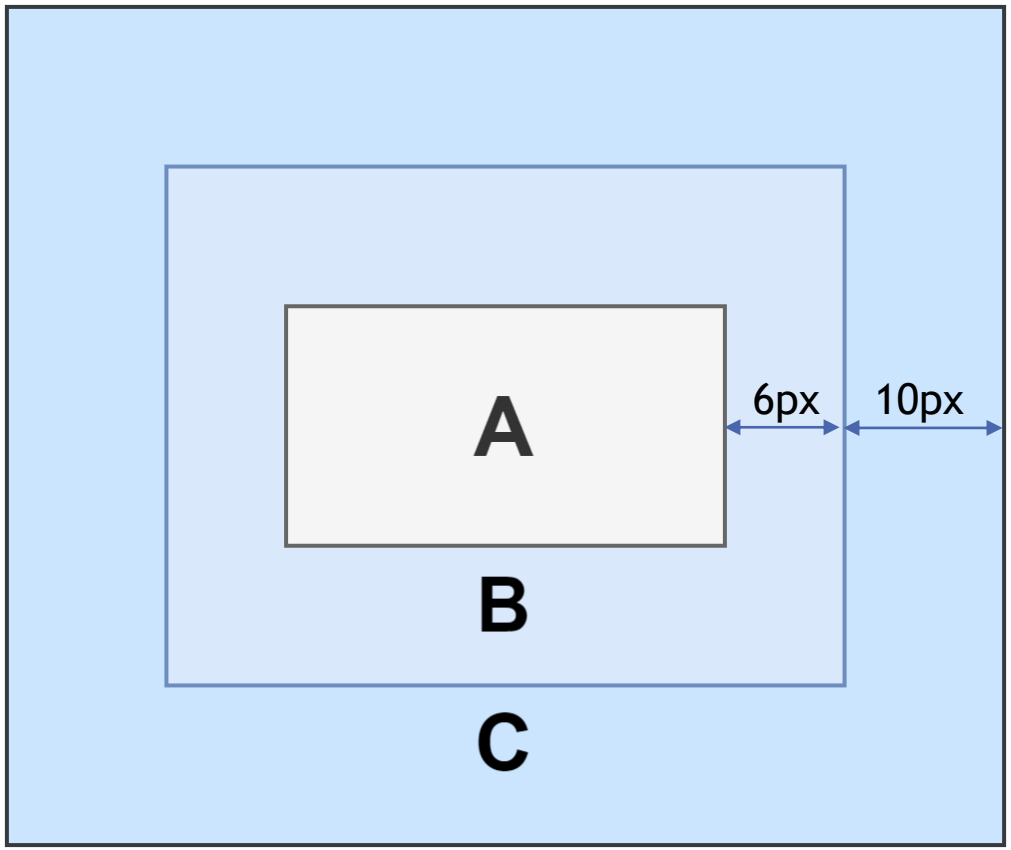
Identified Object



Gaussian Blur Applied

Determining Count

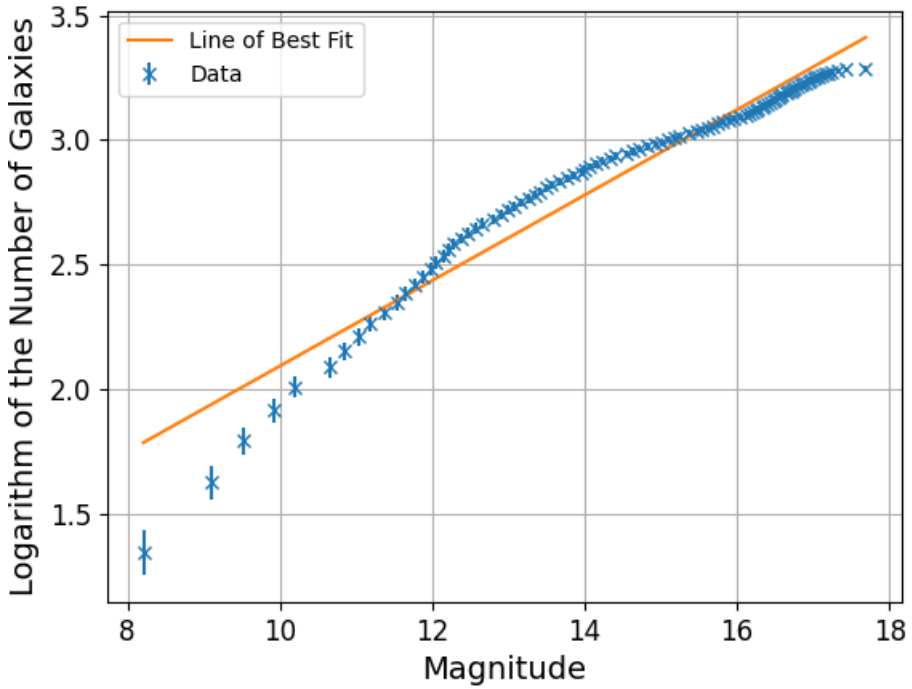
- Used an additional 10-pixel width for local background.
- Ignored background pixels > mean + 1 S.D.
- Discarded object pixels < background + 2 S.D.
- Count = sum of pixels brightness's.



Regions used for analysis.
A: Initial region
B: Buffer region
C: Local background

Results

- Converted count to magnitude.



Graph of $\log_{10}$ of the cumulative number of galaxies against magnitude (m>8).

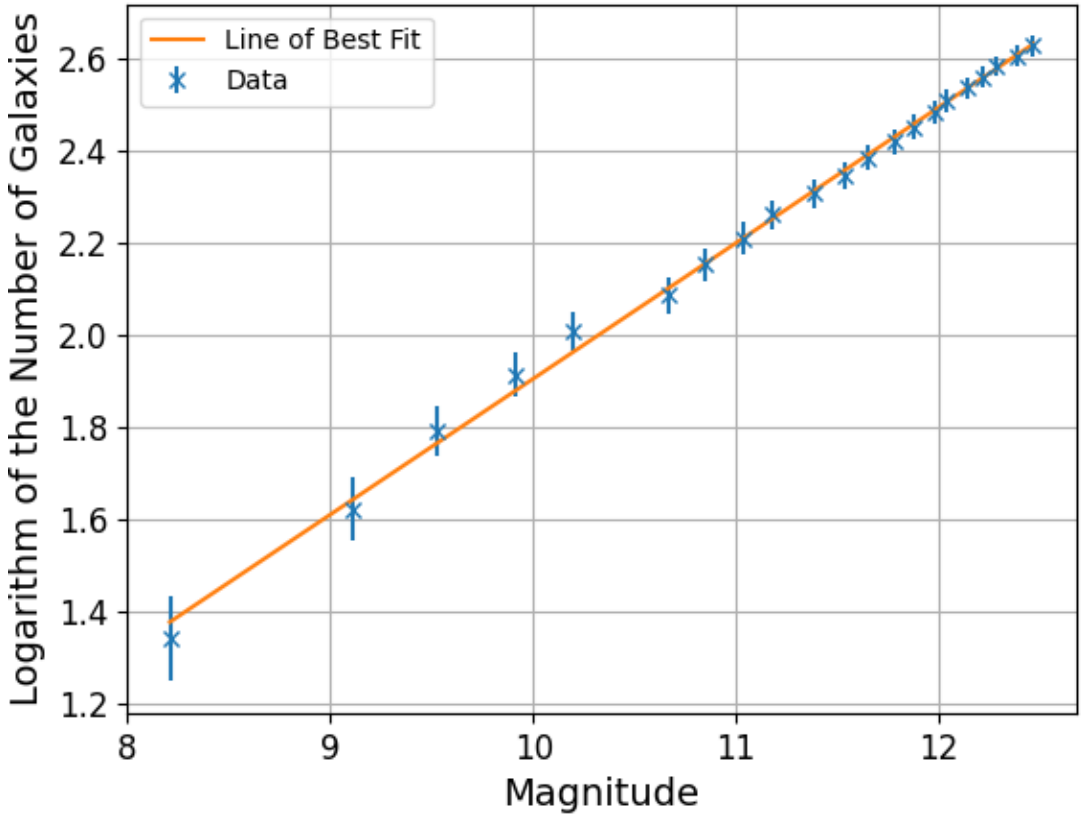
$$m = ZP_{inst} - 2.5\, log_{10}\,(counts)$$

- **Gradient of 0.172 $\pm$ 0.004.**
- Uncertainty derived from $\sqrt{N}$, the uncertainty in cumulative number.
- Disagreed with the theoretical value of 0.6 by 71.3%

Discussion of Results

- Disagreement could be attributable to multiple factors:

1. Limitations of theoretical equation.
2. Analysis of image.
3. Scale of image.



Graph of $\log_{10}$ of the cumulative number of galaxies against magnitude for a reduced range ($8<m<12.5$).

Scale of Image

Cosmological principle: universe exhibits homogeneity at large scales.

Homogeneity observable at magnitudes > 300Mpc [1].

Specific height width and depth data unavailable.

[1] Scrimgeour et al., "The WiggleZ Dark Energy Survey: the transition to large-scale cosmic homogeneity," MNRAS, Vol. 425, Issue 1, Sept. 2012, https://doi.org/10.1111/j.1365-2966.2012.21402.x

Conclusion

- Introduced the 1-dimensional equation that models homogeneity in the universe.
- Explained the methods used for cropping the image and removing artifacts and noise.
- Described the process used to create a catalogue of galactic objects and determine their magnitude.
- Discussed the factors resulting in the discrepancy of our result, including the assumptions of the homogeneity equation, analysis of image and limitations of the image provided.