Photometric extraction from the Processed DATA

This assignment will be on the processed UBVR data of the star field. By processed date we mean the date which has been BIAS corrected and FLAT fielded.

For this Lab please refered to the paper by E. Bertin and S. Arnouts (1996) "***SExtractor: Software for source extraction***" A&A Supplement Series **Vol. 117**, page 393-404. This paper has been shared with you in the course web page.

As used in this paper we are going to estimate the mode with:

$$\text{mode} = 2.5 \times \text{median} - 1.5\ \text{mean} \tag{1}$$

This expression is different from the usual approximation

$$\text{mode} = 3.0 \times \text{median} - 2.0\ \text{mean} \tag{2}$$

(e.g. Kendall & Stuart 1977), but was found, from the simulations, to be more accurate with our clipped distributions.

1. Determination of the SKY value:

So for all the processed UBVR data of the star field $I[i,j]$:

i) Determine the MODE $M_0 = MODE(I[i,j])$ using (Equ. 01.)

ii) Compute the Standard Deviation $\sigma_0 = \frac{1}{N_0}\sqrt{\sum_{i,j}(I[i,j] - M_0)^2}$ where N_0 is the total number of pixel of a image.

iii) Do a $\pm 3\sigma_0$ rejection and store the image in a Spars Matrix: $SKY_1[i,j,I[i,j]]$. Simultaneously store the Positive and Negative rejection in 2 different Spars Matrix:

$If\ (I[i,j] - M_0) > +3\sigma_0 \dashrightarrow St[i,j,I[i,j],l]$ Where l is the star Number (will be used while clustering the pixels in Q.2

$If\ (I[i,j] - M_0) < -3\sigma_0 \dashrightarrow D_0[i,j,I[i,j]]$

iv) Iteratively re-compute the MODE $M_k = MODE(SKY_k[i,j,I[i,j]])$ using (Equ. 01.)

v) Iteratively re-compute the Standard Deviation $\sigma_k = \frac{1}{N_k}\sqrt{\sum_{i,j}(I[i,j] - M_k)^2}$ where N_k is the total number of pixel of the Sparse Matrix $SKY_k[i,j,I[i,j]]$ after k iterations.

vi) Do a $\pm 3\sigma_k$ rejection and store the image in a Spars Matrix: $SKY_k[i,j,I[i,j]]$. Simultaneously append / store the Positive and Negative rejection in 2 different Spars Matrix: $If\ (I[i,j] - M_k) > +3\sigma_k \dashrightarrow APPEND:\ St[i,j,I[i,j],l]$

Where l is the star Number (will be used while clustering the pixels in Q.2.

$If\ (I[i,j] - M_k) < -3\sigma_k \dashrightarrow APPEND:\ D_k[i,j,I[i,j]]$

Continue the Iteration till: $|\sigma_{k-1} - \sigma_k| \ll +\epsilon$ THEN **SET** $SKY = M_k$.

vii) Plot$(M_k \ \ vs\ k)$; $(\sigma_k \ \ vs\ k)$; $(N_k \ \ vs\ k)$ and **2-D** Plot in i, j of $D_k[i, j, I[i, j]]$ starting with $k = 0$. (In **2-D** Plot in i, j of $D_k[i, j, I[i, j]]$ use different **Colours / Symbols** to represent the iteration number k on the same **2-D** plot. Compare the **2-D** plot with the images. Explain what is $D_k[i, j, I[i, j]]$? **[20]**

2. Clustering the pixels:

This process can be done within the Iterations k. After every iteration is completed in **Problem 2** do:

Find the Neighboring pixels:

i) Find $[i_0, j_0]$ the brightest pixel of $St[i_0, j_0, I_{max}[i_0, j_0], l]$ set $l = 1$ … … .

ii) Find the neighboring pixel in the Sparse Matrix $SKY_k[i, j, I[i, j]]$:

$[i_0 - 1, j_0 + 1]$	$[i_0, j_0 + 1]$	$[i_0 + 1, j_0 + 1]$
$[i_0 - 1, j_0]$	$[i_0, j_0]$	$[i_0 + 1, j_0]$
$[i_0 - 1, j_0 - 1]$	$[i_0, j_0 - 1]$	$[i_0 + 1, j_0 - 1]$

Set the same $l = 1$for the Neighboring pixels. Iteratively check for the neighbors of the 8 Neighboring pixels set $l = 1$ for them also. Continue till all neighbors found. (The iterative process should end if No Neighbor OR if l has already been assigned.

iii) Iteratively select the new $[i_0, j_0]$ the brightest pixel of $St[i_0, j_0, I_{max}[i_0, j_0], l]$ from the remaining pixels in the Sparse matrix $St[i_0, j_0, I_{max}[i_0, j_0], l]$ where l is not set to 1. Set $l = 1 + 1 = 2$ repeat *(ii)*.

iv) In the next Iteration of **Problem 2**, $St[i, j, I[i, j], l]$ is appended with new pixels. These new pixels should be checked for neighbors of previous sets.

IF it neighbors any of the previous set; THEN SET l to that of the Neighbor ELSE SET l with a new No.

v) When l is SET for all the pixels of the Sparse Matrix $St[i, j, I[i, j], l]$; Subtract the Final SKY : $St[i, j, I[i, j], l] - SKY$ from the $I[i, j]$ of the SET. **[20]**

3. Summing the pixels for Star Flux and Determining the Star's Instrumental Magnitude.

For each l sum the $F_l = \sum_{i,j}(I[i, j] - SKY)$

Determine the Star's Instrumental Magnitude : $m_l = 25 - 2.5Log_{10}(F_l)$. **[05]**

4. Computing Star Centroid:

$i_l = \frac{\sum_{i,j}\{(I[i,j]-SKY)\times i\}}{\sum_{i,j}(I[i,j]-SKY)}$; $j_l = \frac{\sum_{i,j}\{(I[i,j]-SKY)\times j\}}{\sum_{i,j}(I[i,j]-SKY)}$; **[05]**

$[i_l, j_l]$ is floating point (Sub-pixel accuracy).

5. Tabulate: **[05]**

l	i_l	j_l	F_l	m_l
1				
2				
…				

6. Mark the Stars in a **2-D** plot in $[i, j]$ with a filled circle where the circle radius is proportional to m_l. Compare with original image. **[05]**