Contents


```
clear all;
```

read fits file

```
Sb=FITS.read2sim('m93_b.fits');
Sv=FITS.read2sim('m93_v.fits');
table = readtable('m93_cata');
gnd_true_table= readtable('theorem/387M.csv'); %first column is B_V second col is V
distance = 881;%distance of the cluster in pc
```

```
Warning: Column headers from the file were modified to make them valid MATLAB
identifiers before creating variable names for the table. The original column
headers are saved in the VariableDescriptions property.
Set 'VariableNamingRule' to 'preserve' to use the original column headers as
table variable names.
```

B-layer processing

```
image_b = abs(fitsread('m93_b.fits'));
image_b_raw = image_b;
%whos data
%fitsdisp('20200508_M57-001b100.fits');
image_b = log(image_b);
figure();
imagesc(abs(image_b));
% Low pass filtering
h = fspecial('gaussian', 100, 1);
image_b_f = imfilter(image_b, h);
% threshold
% m36: 6.7
image_b_f(image_b_f<7.0) = 0; %MODIFY THIS VALUE!!
% star region
image_b_ff = image_b_f;
image_b_ff(image_b_ff > 0) = 1;
figure();
imagesc(image_b_ff);
title('star region');
image_b_raw = image_b_raw.*image_b_ff;
figure();
imagesc(image_b_raw);
title('Processed Image');
% find local maximum
image_b_max = imregionalmax(image_b_f);
figure();
imagesc(image_b_max);
title('Star peaks');
fprintf('found %d stars in B layer!\n', sum(sum(image_b_max)));
```

```
found 266 stars in B layer!
```

V layer processing

```
image_v = abs(fitsread('m93_v.fits'));
image_v_raw = image_v;
```

```
%whos data
%fitsdisp('20200508_M57-001b100.fits');
image_v = log(image_v);
figure();
imagesc(image_v);
% Low pass filtering
h = fspecial('gaussian', 100, 1);
image_v_f = imfilter(image_v, h);
figure();
imagesc(image_v_f);
% threshold
% m36 :7
image_v_f(image_v_f<7.8) = 0; %MODIFY THIS VALUE!!
% star region
image_v_ff = image_v_f;
image_v_ff(image_v_ff > 0) = 1;
figure();
imagesc(image_v_ff);
title('star region');
image_v_raw = image_v_raw.*image_v_ff;
% find local maximum
image_v_max = imregionalmax(image_v_f);
fprintf('found %d stars in V layer!\n', sum(sum(image_v_max)));
```

Star Matching, star magnitude, dM caculate

```
[height, width] = size(image_v_max);
result = [];
match = 0;
error =1;
r = 10;
err_b = 0.003; %error of catalog
err_v = 0.003;
sz = size(table);
h = sz(1);
dMb =[];
dMv =[];
for i = 1+r : height -r
    for k = 1+r : width -r
        match = 0;
        if image_v_max(i,k) == 1
            wcs_b = xy2coo(Sb(1), i, k).Cat;
            wcs_v = xy2coo(Sv(1), i, k).Cat;
            xy = coo2xy(Sb(1), wcs_v(1), wcs_v(2)).Cat;
            ii = round(xy(1));
            kk = round(xy(2));
            % find whether B also match
            if(sum(sum(image_b_max(ii-error:ii+error, kk-error:kk+error))) == 1)
                match = 1;
            end
            if match == 1
                %1.1 calculate dMb
                for g = 1:h
                    dV = sqrt((table{g, 1}- rad2deg(wcs_v(1)))^2 + (table{g,2}-rad2deg(wcs_v(2)))^2);
                    dB = sqrt((table{g, 1}- rad2deg(wcs_b(1)))^2 + (table{g,2}-rad2deg(wcs_b(2)))^2); %error distance
                    if(dB < err_b)
                        t = table{g, 'Bmag'}-(-2.5)*log10(sum(sum(image_b_raw(i-r: i+r,k-r:k+r))));
                        dMb = [dMb, t];
                        fprintf('B match at x:%d, y:%d, dM=%d\n', i, k, t);
                    end
                    if(dV < err_v)
                        t = table{g, 'Vmag'}-(-2.5)*log10(sum(sum(image_b_raw(i-r: i+r,k-r:k+r))));
                        dMv = [dMv, t];
                       fprintf('V match at x:%d, y:%d, dM=%d\n', i, k, t);
                    end
                end

                %2. search through a small region in B image to find peak
                peak = 0;

                for m = ii-error: ii+error
```

```
                    for n = kk - error: kk+error
                        if  m>0 && m<=2048 && n>0 &&n<=2048&&image_b_max(m, n) == 1
                            peak = 1;
                            result = [result; log10(sum(sum(image_b_raw(m-r: m+r,n-r:n+r)))),...
                                log10(sum(sum(image_v_raw(i-r: i+r, k-r:k+r))))];
                            break;
                        end
                    end
                    if peak == 1
                        break;
                    end
                end
                if peak ~= 1
                    fprintf('NO MATCHED PEAK IN B IMAGE!\n');
                end
            end
        end
    end
end
% instrument mag

result = result * -2.5;
```

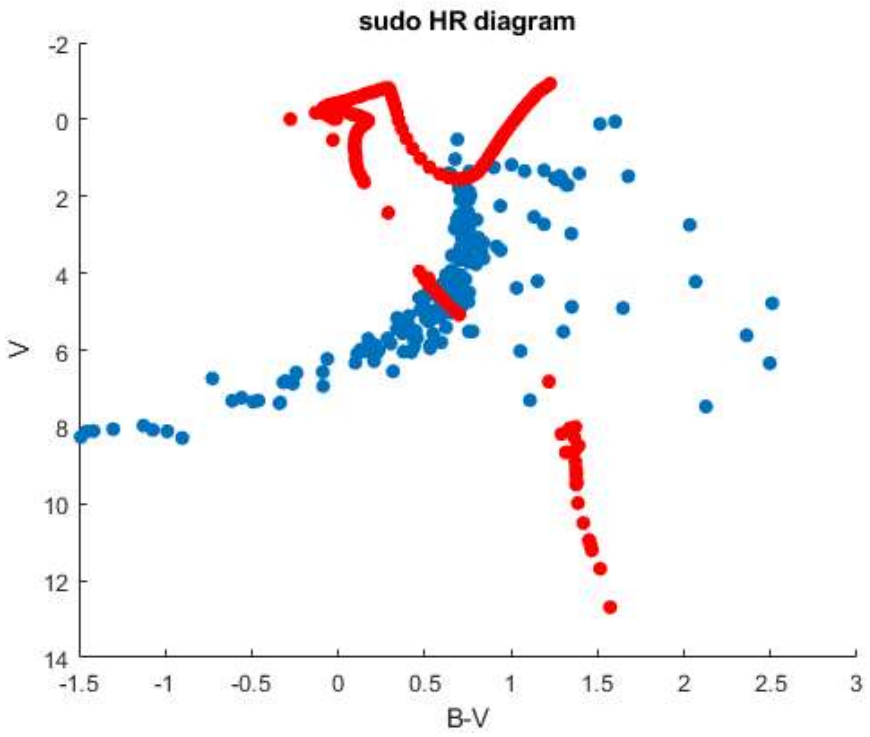
```
B match at x:206, y:778, dM=2.941550e+01
V match at x:206, y:778, dM=2.809550e+01
B match at x:242, y:613, dM=2.953978e+01
V match at x:242, y:613, dM=2.881978e+01
B match at x:307, y:883, dM=2.331667e+01
V match at x:307, y:883, dM=2.243467e+01
B match at x:310, y:1013, dM=2.795774e+01
V match at x:310, y:1013, dM=2.811774e+01
B match at x:530, y:254, dM=3.289705e+01
V match at x:530, y:254, dM=3.178705e+01
B match at x:646, y:1852, dM=2.514093e+01
V match at x:646, y:1852, dM=2.480093e+01
B match at x:689, y:905, dM=2.759958e+01
V match at x:689, y:905, dM=2.569958e+01
B match at x:694, y:919, dM=2.757000e+01
V match at x:694, y:919, dM=2.567000e+01
B match at x:701, y:950, dM=2.335121e+01
V match at x:701, y:950, dM=2.371121e+01
B match at x:770, y:1572, dM=2.977387e+01
V match at x:770, y:1572, dM=2.903387e+01
B match at x:775, y:1614, dM=2.654690e+01
V match at x:775, y:1614, dM=2.626690e+01
B match at x:815, y:1934, dM=2.871973e+01
V match at x:815, y:1934, dM=2.855973e+01
B match at x:827, y:1132, dM=2.275505e+01
V match at x:827, y:1132, dM=2.273505e+01
B match at x:831, y:1106, dM=2.625306e+01
V match at x:831, y:1106, dM=2.623306e+01
B match at x:847, y:1061, dM=3.169970e+01
V match at x:847, y:1061, dM=3.055970e+01
B match at x:874, y:986, dM=2.665206e+01
V match at x:874, y:986, dM=2.670206e+01
B match at x:899, y:320, dM=2.711579e+01
V match at x:899, y:320, dM=2.707579e+01
V match at x:906, y:1802, dM=2.946068e+01
B match at x:910, y:760, dM=2.748306e+01
V match at x:910, y:760, dM=2.768306e+01
B match at x:928, y:226, dM=2.810302e+01
V match at x:928, y:226, dM=2.755302e+01
B match at x:946, y:1204, dM=2.186002e+01
V match at x:946, y:1204, dM=2.130002e+01
B match at x:971, y:1209, dM=2.368908e+01
V match at x:971, y:1209, dM=2.312908e+01
B match at x:981, y:761, dM=2.680705e+01
V match at x:981, y:761, dM=2.570705e+01
B match at x:992, y:655, dM=2.713699e+01
V match at x:992, y:655, dM=2.879699e+01
B match at x:1000, y:822, dM=2.695176e+01
```

V match at x:1000, y:822, dM=2.975176e+01
B match at x:1002, y:968, dM=2.491008e+01
V match at x:1002, y:968, dM=2.589008e+01
B match at x:1018, y:1152, dM=2.169548e+01
V match at x:1018, y:1152, dM=2.177448e+01
B match at x:1020, y:1601, dM=3.043704e+01
V match at x:1020, y:1601, dM=2.922704e+01
B match at x:1031, y:989, dM=2.220167e+01
V match at x:1031, y:989, dM=2.318167e+01
B match at x:1047, y:1685, dM=2.638674e+01
V match at x:1047, y:1685, dM=2.621674e+01
B match at x:1050, y:1159, dM=2.629967e+01
V match at x:1050, y:1159, dM=2.701967e+01
B match at x:1067, y:1212, dM=2.956677e+01
V match at x:1067, y:1212, dM=2.886677e+01
B match at x:1067, y:1212, dM=2.880677e+01
V match at x:1067, y:1212, dM=2.839677e+01
B match at x:1075, y:944, dM=2.479769e+01
V match at x:1075, y:944, dM=2.121769e+01
B match at x:1075, y:944, dM=2.261069e+01
V match at x:1075, y:944, dM=2.232669e+01
B match at x:1077, y:804, dM=2.522091e+01
V match at x:1077, y:804, dM=2.593091e+01
B match at x:1085, y:1563, dM=2.860515e+01
V match at x:1085, y:1563, dM=2.801515e+01
B match at x:1092, y:1202, dM=2.534558e+01
V match at x:1092, y:1202, dM=2.676558e+01
B match at x:1094, y:633, dM=2.998017e+01
V match at x:1094, y:633, dM=2.861017e+01
B match at x:1111, y:830, dM=2.417739e+01
V match at x:1111, y:830, dM=2.402939e+01
B match at x:1123, y:383, dM=2.919305e+01
V match at x:1123, y:383, dM=2.854305e+01
B match at x:1140, y:1049, dM=2.393281e+01
V match at x:1140, y:1049, dM=2.354881e+01
B match at x:1189, y:1830, dM=2.910474e+01
V match at x:1189, y:1830, dM=2.709474e+01
B match at x:1263, y:1185, dM=2.642431e+01
V match at x:1263, y:1185, dM=2.522431e+01
B match at x:1278, y:580, dM=2.788499e+01
V match at x:1278, y:580, dM=2.657499e+01
B match at x:1305, y:892, dM=2.477821e+01
V match at x:1305, y:892, dM=2.499821e+01
B match at x:1305, y:892, dM=2.692821e+01
V match at x:1305, y:892, dM=2.629821e+01
B match at x:1313, y:1162, dM=2.829297e+01
V match at x:1313, y:1162, dM=2.896297e+01
B match at x:1363, y:1250, dM=2.914740e+01
V match at x:1363, y:1250, dM=2.987740e+01
B match at x:1404, y:778, dM=2.848870e+01
V match at x:1404, y:778, dM=2.643870e+01
B match at x:1444, y:1065, dM=3.052635e+01
V match at x:1444, y:1065, dM=2.669635e+01
B match at x:1450, y:233, dM=3.067114e+01
V match at x:1450, y:233, dM=2.779114e+01
B match at x:1458, y:220, dM=2.979980e+01
V match at x:1458, y:220, dM=2.691980e+01
B match at x:1513, y:536, dM=3.029013e+01
V match at x:1513, y:536, dM=2.974013e+01
B match at x:1578, y:130, dM=3.252088e+01
V match at x:1578, y:130, dM=3.162088e+01
B match at x:1622, y:791, dM=2.344983e+01
V match at x:1622, y:791, dM=2.317983e+01
B match at x:1640, y:1656, dM=2.438108e+01
V match at x:1640, y:1656, dM=2.470108e+01
B match at x:1718, y:1702, dM=2.497526e+01
V match at x:1718, y:1702, dM=2.462526e+01
B match at x:1835, y:504, dM=2.872413e+01
V match at x:1835, y:504, dM=2.835413e+01
B match at x:1865, y:666, dM=2.539440e+01
V match at x:1865, y:666, dM=2.476440e+01
B match at x:1903, y:556, dM=2.832221e+01
V match at x:1903, y:556, dM=2.802221e+01

diagram

```
result(:,1) = result(:,1) + median(dMb);
result(:,2) = result(:,2) + median(dMv);
fprintf('dM of B: %f\n', median(dMb));
fprintf('dM of V: %f\n', median(dMv));
B_V = result(:,1) - result(:,2);
V = result(:,2) -5*log10(distance)+5;
B_V_true = gnd_true_table{:,1};
V_true = gnd_true_table{:,2};
figure();
HR = axes;
scatter(HR ,B_V, V, 'filled'); % our data
hold;
scatter(HR, B_V_true, V_true, 'filled','r');
HR.YDir = 'reverse';
title('sudo HR diagram');
xlabel('B-V');
ylabel('V');
```

```
dM of B: 27.126387
dM of V: 26.702064
Current plot held
```



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