Notes on Current Method Applied to New Grainy Image

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Contents

1 Introduction

Using a new test image, we see how robust our method is applied to a different (and most likely more realistic) image. The new image measures 1296 x 966 in size, compared to out old image size of 449 x 321. The result is that out image runs slower, but not linearly so.

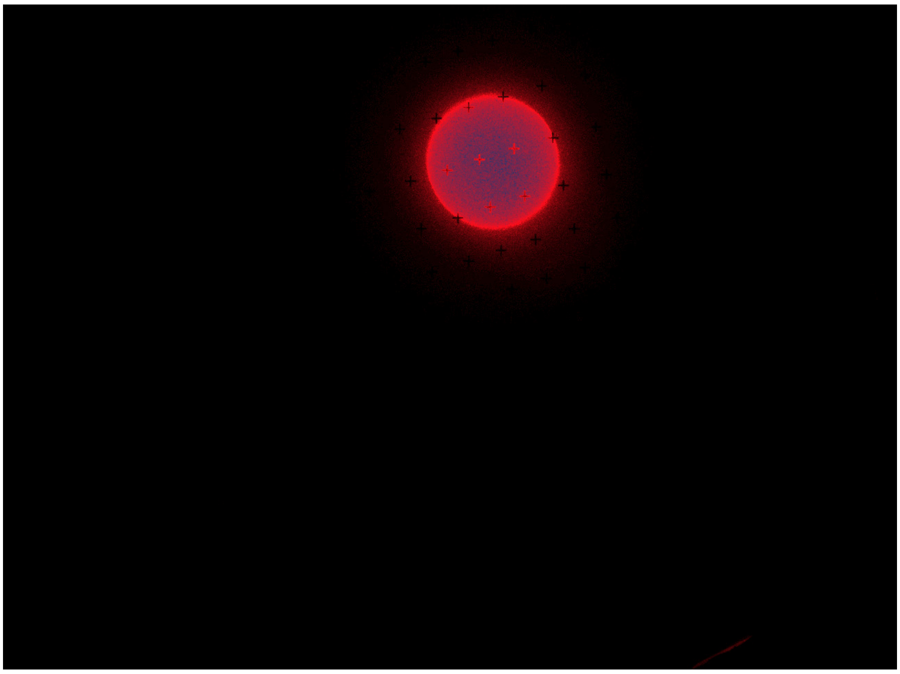


Figure 1 I have used a different color table here (Stern Special) because the black and white image was too dim. The fiducials are staggered and can be seen extending off the solar limbs.

2 How Slow is Slow

Table 1 lays out where our code takes the most time. Part of the process of making the code faster will be looking at which routines are called sparsely but still consume a lot of computing time, like `sort()`, for example.

3 Code Flow Chart

Table 1. Time (Total elapsed: 0.23658586 s)

Routine	Times Called	Time Taken	Time Taken	A Number
SORT	64	0.02678	0.02678	1
CONVOL	1	0.02617	0.02617	1
SMOOTH	2	0.01668	0.01668	1
ROTATE	5	0.01565	0.01565	1
SHIFT	8	0.00713	0.00713	1
HISTOGRAM	2	0.00706	0.00706	1
LABEL_REGION	2	0.00641	0.00641	1
ERODE	2	0.00385	0.00385	1
TOTAL	141	0.00318	0.00318	1
DILATE	2	0.00262	0.00262	1
FLOAT	121	0.00200	0.00200	1
WHERE	38	0.00161	0.00161	1
MAX	10	0.00087	0.00087	1
RESOLVE_ROUTINE	1	0.00026	0.00026	1
BYTARR	10	0.00018	0.00018	1
REPLICATE	14	0.00006	0.00006	1
STRTRIM	50	0.00005	0.00005	1
FIX	21	0.00005	0.00005	1
FINDGEN	8	0.00004	0.00004	1
READF	10	0.00003	0.00003	1
PROFILER	1	0.00003	0.00003	1
CREATE_STRUCT	11	0.00003	0.00003	1
ON_ERROR	73	0.00003	0.00003	1
STRMID	34	0.00002	0.00002	1
FILE_LINES	1	0.00002	0.00002	1
GETTOK	2	0.00001	0.00002	0
STRTOK	10	0.00002	0.00002	1
REFORM	39	0.00002	0.00002	1
FLTARR	19	0.00002	0.00002	1
SQRT	62	0.00002	0.00002	1
SCOPE_VARFETCH	12	0.00002	0.00002	1
STRCOMPRESS	12	0.00002	0.00002	1
DOUBLE	10	0.00001	0.00001	1
OPENR	1	0.00001	0.00001	1
N_PARAMS	36	0.00001	0.00001	1
PRINT	1	0.00001	0.00001	1
INDGEN	3	0.00001	0.00001	1
MIN	8	0.00001	0.00001	1
FINITE	12	0.00001	0.00001	1
MESSAGE	1	0.00001	0.00001	1
DEFSYSV	2	0.00001	0.00001	1
STRING	12	0.00001	0.00001	1
STRLEN	30	0.00001	0.00001	1
FREE_LUN	1	0.00001	0.00001	1
CATCH	10	0.00001	0.00001	1
PRODUCT	5	0.00000	0.00000	1
ARRAY_EQUAL	5	0.00000	0.00000	1
BYTE	4	0.00000	0.00000	1
MAKE_ARRAY	2	0.00000	0.00000	1
SYSTIME	2	0.00000	0.00000	1
STRPOS	3	0.00000	0.00000	1
ABS	13	0.00000	0.00000	1
TAG_NAMES	1	0.00000	0.00000	1
ISA	9	0.00000	0.00000	1
SKIP_LUN	1	0.00000	0.00000	1
PTR_FREE	1	0.00000	0.00000	1
PTR_NEW	2	0.00000	0.00000	1
PTRARR	1	0.00000	0.00000	1
STRUPCASE	1	0.00000	0.00000	1
INTARR	1	0.00000	0.00000	1

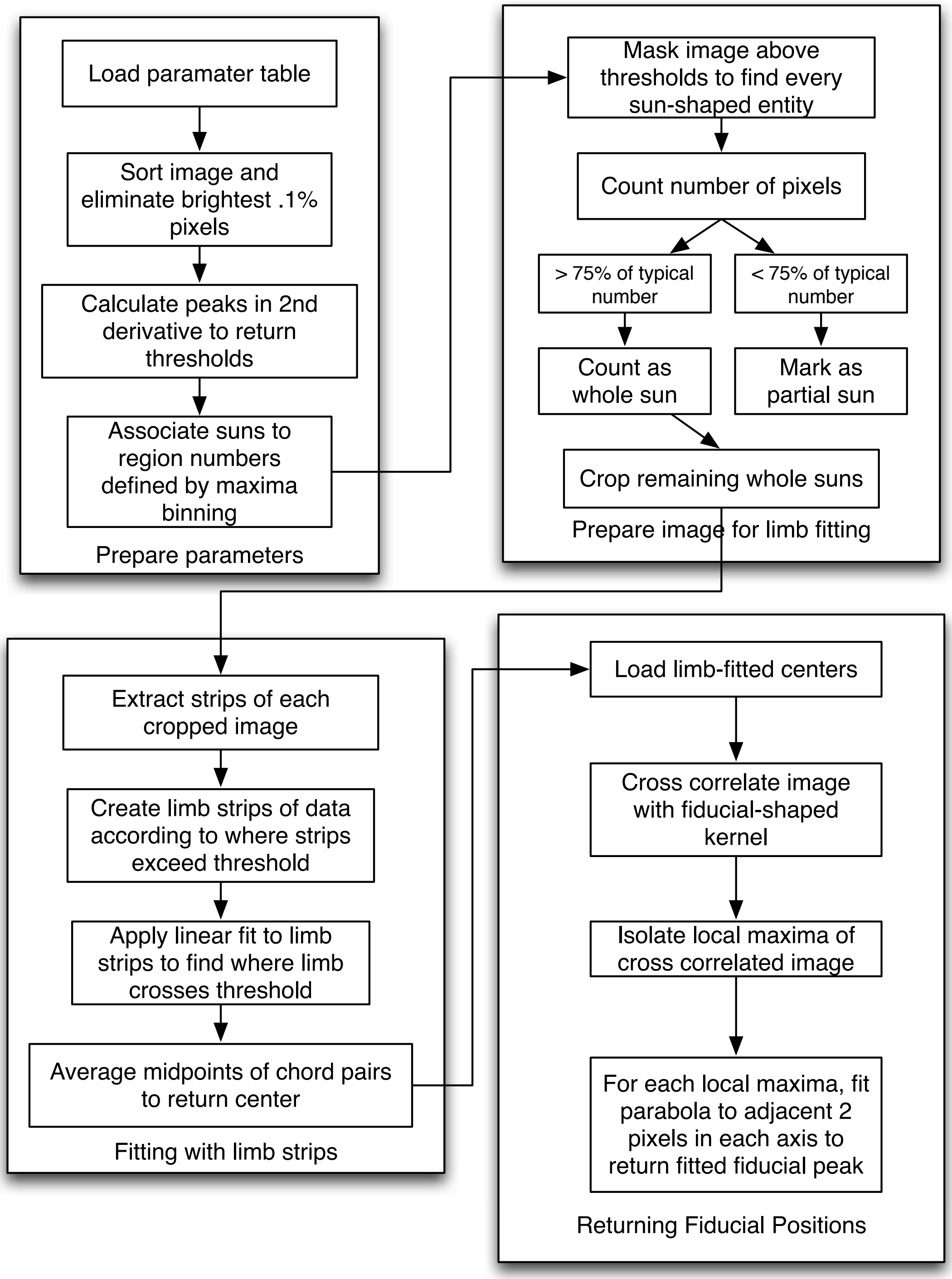

Load paramater table
Sort image and eliminate brightest .1% pixels
Calculate peaks in 2nd derivative to return thresholds
Associate suns to region numbers defined by maxima binning
Prepare parameters
Mask image above thresholds to find every sun-shaped entity
Count number of pixels
> 75% of typical number
< 75% of typical number
Count as whole sun
Mark as partial sun
Crop remaining whole suns
Prepare image for limb fitting
Extract strips of each cropped image
Create limb strips of data according to where strips exceed threshold
Apply linear fit to limb strips to find where limb crosses threshold
Average midpoints of chord pairs to return center
Fitting with limb strips
Load limb-fitted centers
Cross correlate image with fiducial-shaped kernel
Isolate local maxima of cross correlated image
For each local maxima, fit parabola to adjacent 2 pixels in each axis to return fitted fiducial peak
Returning Fiducial Positions

Figure 2

4 The Dreaded Nested For Loop

This is taken straight from Albert's C++ code:

```
for (int m = 1; m < correlation.rows-1; m++)
    {
        for (int n = 1; n < correlation.cols-1; n++)
        {
            thisValue = correlation.at<float>(m,n);
            if(thisValue > threshold)
            {
                //Checks if cross correlated pixel is higher than adjacent pixels
                if((thisValue > correlation.at<float>(m, n + 1)) &
                   (thisValue > correlation.at<float>(m, n - 1)) &
                   (thisValue > correlation.at<float>(m + 1, n)) &
                   (thisValue > correlation.at<float>(m - 1, n)))
                {
                    redundant = false;
                    for (unsigned int k = 0; k < pixelFiducials.size(); k++)
                    {
                        // Checks if previous fiducial correlation values are within 2 fiducial lengths of each other. If so, use the one with a higher correlation value
                        if (abs(pixelFiducials[k].y - m) < fiducialLength*2 &&
                            abs(pixelFiducials[k].x - n) < fiducialLength*2)
                        {
                            redundant = true;
                            thatValue = correlation.at<float>((int) pixelFiducials[k].y,(int) pixelFiducials[k].x);
                            Choose the "fiducial" with a higher correlation value
                            if ( thisValue > thatValue)
                            {
                                pixelFiducials[k] = cv::Point2f(n,m);
                            }
                            // Break out of this because there should only be one instance of this per run
                            break;
                        }
                    }
                    // Regardless of whether or not the fiducial was replaced, break out of the loop
                    if (redundant == true)
                        continue;

                    // If we're short a few entries for fiducials, extend the array
                    if ( (int) pixelFiducials.size() < numFiducials)
                    {
                        pixelFiducials.add(n, m);
                    }
                    else
                    {
                        // Dealing with too many fiducials
                        minValue = std::numeric_limits<float>::infinity();;
                        minIndex = -1;
                        for (int k = 0; k < numFiducials; k++)
                        {
                            if (correlation.at<float>((int) pixelFiducials[k].y,(int) pixelFiducials[k].x)
                                < minValue)
                            {
                                minIndex = k;
                                minValue = correlation.at<float>((int) pixelFiducials[k].y,(int) pixelFiducials[k].x);
                            }
                        }
                        if (thisValue > minValue)
                        {
                            pixelFiducials[minIndex] = cv::Point2f(n, m);
                        }
                    }
                }
            }
        }
    }
```

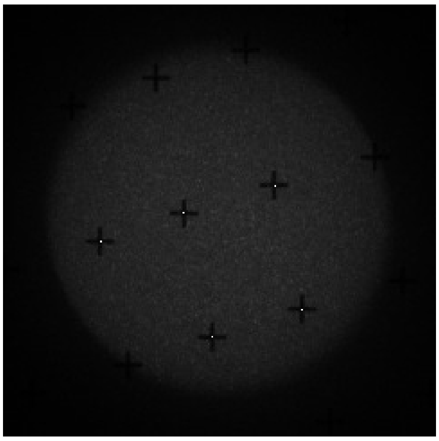
Table 2. Comparison of Fiducial Positions

Fiducial Number	Albert's X	My X	Albert's Y	My Y
0	674.6796	N/A	151.0038	N/A
1	796.3074	N/A	195.0324	N/A
2	740.4443	741.185	210.6342	211.289
3	690.2598	690.985	226.1973	226.961
4	643.4235	644.227	241.8869	242.636
5	755.8672	756.764	279.6622	280.443
6	706.0065	706.809	295.3022	295.957

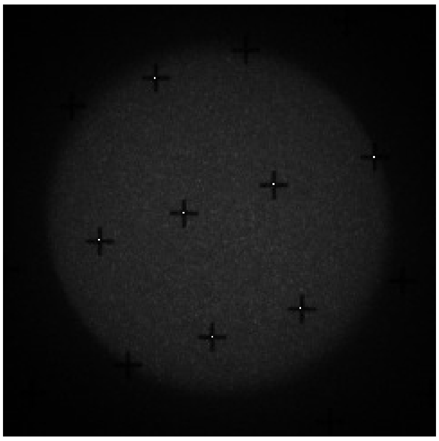
Table 3. Side Crop Test

Amount Cropped from Limb (pixels)	$x_{\text{True}} - x_{\text{Cropped}}$	$y_{\text{True}} - y_{\text{Cropped}}$
10	-1.17771	-0.0108643
20	-4.07970	-0.0376663
30	-7.63260	-0.0522766
40	-11.7287	-0.0585175
50	-16.2043	-0.0185776
60	-20.9117	-0.0872879
70	-25.7588	-0.277687
80	-30.8586	-0.321724
90	-36.1318	-0.318489

5 Comparison to Albert's Code



(a) The fiducials I find



(b) The fiducials Albert finds

Figure 3 My code can't pick up two fiducials due to one or many of the following factors: different kernel, different convolution method, different threshold.

In Table 2 The fiducial positions are typically within 1 pixel of Albert's calculated positions, which is pretty good.

6 Partial Sun Checking

We're motivaed to keep some center data regardless of how cut off a sun may be. To do this, we must quantify the poorness of the fit as more sun is cut off. Figures 4 and 5 aim to quantify the worsenings of the exaluated centers. We start by lining up the edge of the image to the solar limb then cropping in 10 columns.

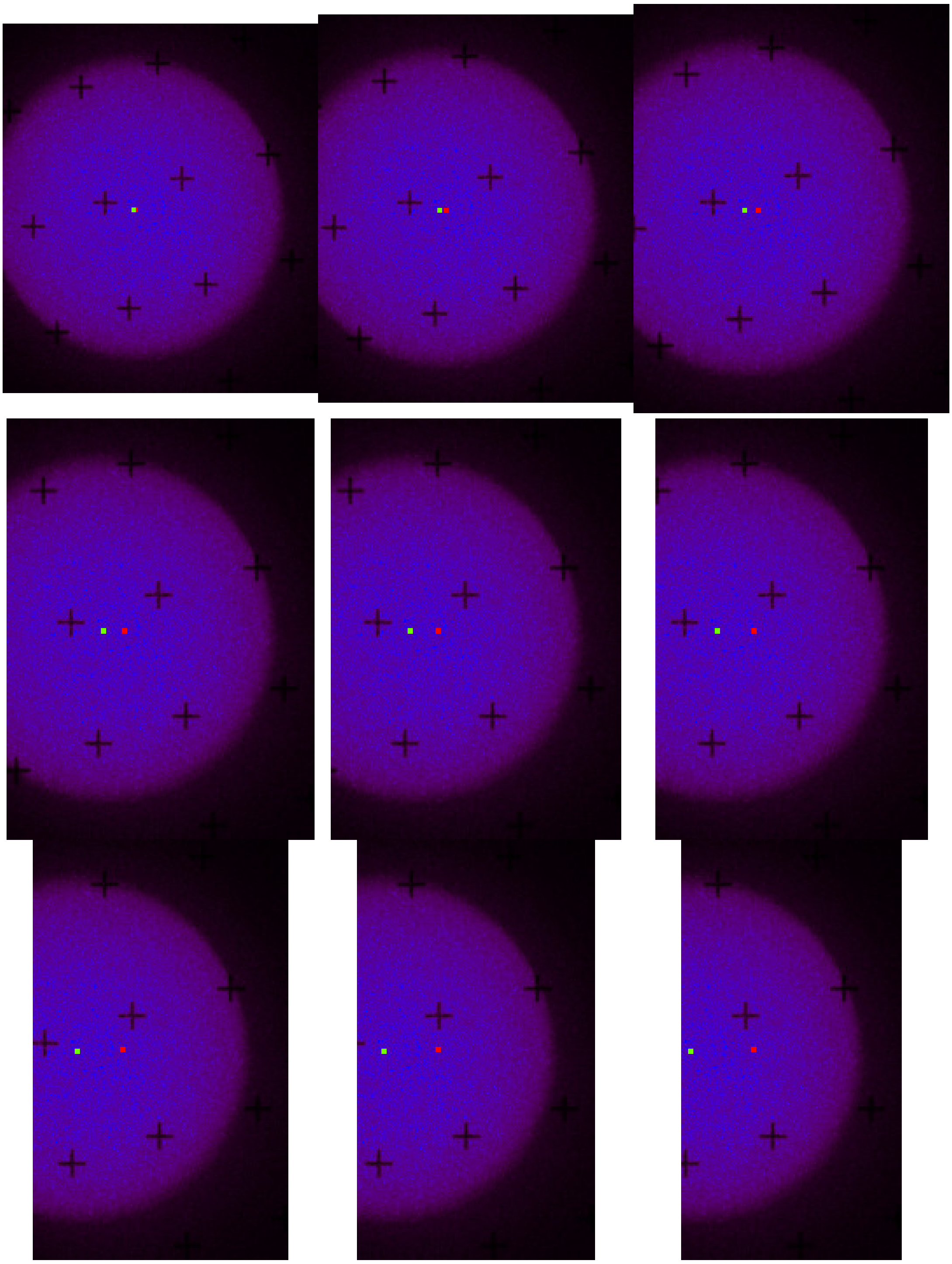


Figure 4 The green pixel is the image's true center and the red pixel is the center of the cropped image. The images are cropped 10 columns at a time.

7 Glaring Problems

I was having trouble with proper thresholding but it was alleviated with increasing the smoothing parameter. *Go parameter block!*

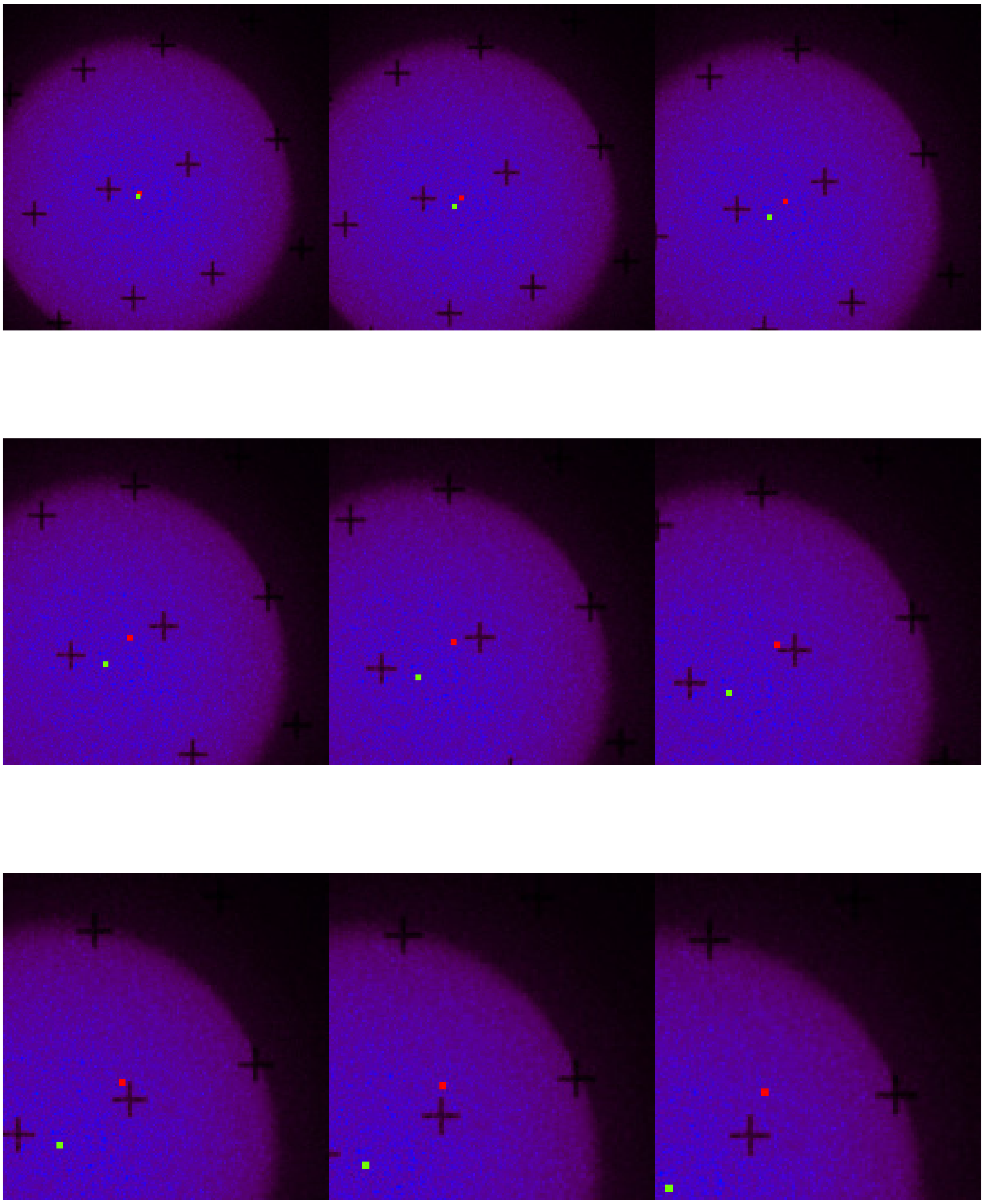


Figure 5 The green pixel is the image's true center and the red pixel is the center of the cropped image. The images are cropped 10 columns at a time.

Table 4. Corner Crop Test

Amount Cropped from Limb (pixels)	$x_{\text{True}} - x_{\text{Cropped}}$	$y_{\text{True}} - y_{\text{Cropped}}$
10	-1.17902	-1.22132
20	-4.23825	-4.28215
30	-8.41805	-8.49775
40	-13.2540	-13.3160
50	-18.2548	-18.0202
60	-23.0267	-22.9181
70	-27.5755	-27.8987
80	-32.1102	-32.4790
90	-36.6139	-37.0980

Table 5. Comparison of Center Positions

Method	X Position	Y Position
Mine	710.811	230.695
Albert's	709.7835	230.1023