

Segmentation And Feature Extraction Of H-Alpha Solar Images Observed From Kodaikanal Solar Observatory

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ABSTRACT

The main aim of our project is to use the H α telescope facility and obtain the images of the Sun in strong H α line whose wavelength is 6563Å. H α telescope consists of Lyot filter which can be tuned to any location on the strong H α absorption line in steps of 0.4Å and images at these locations on the line profile will be obtained. On the images obtained Image Processing techniques such as enhancement and segmentation are applied in order to detect and extract the features for which intensity v/s time graph is plotted. The time series analysis was developed on H α images which were observed for two hours with the time resolution of two minute cadence and derived the intensity at the centre, 0.4Å and 0.8Å of the solar disk and time series graph is plotted. In addition, the evolution of the dark filaments has been examined which leads to the occurrence of the solar flare, which has high impact on earth's climate, space weather and satellite communication.

CHROMOSPHERE

The Chromosphere is the second of the three main layers in the Sun's atmosphere and is roughly 3000 to 5000 kilometers deep. It is the irregular layer above the Photosphere where the temperature rises from 6000°C to about 20,000°C. The name comes from the fact that it has a reddish color, as the visual spectrum of the chromosphere is dominated by deep red H-Alpha spectral line of the hydrogen.

Fig : The Chromosphere

FILAMENTS



Filaments are the large regions of very dense, cool gas, held in a place by magnetic fields. They usually appear long and thin above the chromosphere. The Filaments are cooler than their surroundings hence they appear dark. It will last for a few weeks or months. The gas in the filament will eventually move to a different layer in the Sun and will no longer be visible in an image of the chromosphere which is as shown in the Fig

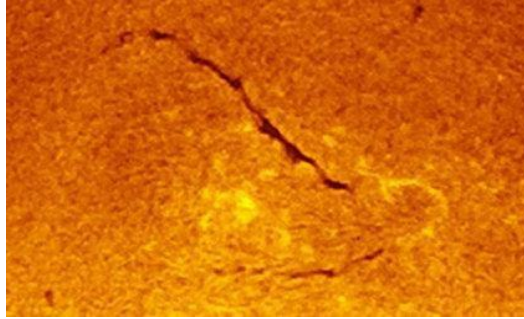
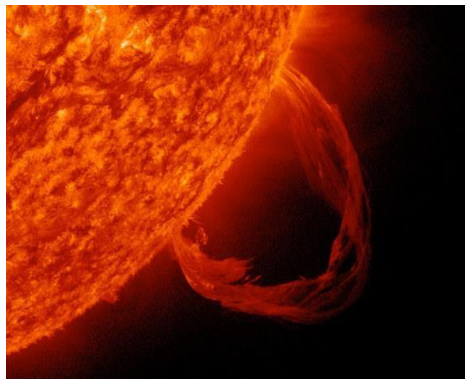


Fig : The Solar Filament

PROMINENCE

A Prominence is a large, bright, gaseous feature extending outwards from the Sun's surface, often in a loop shape. These are anchored to the Sun's surface in the Photosphere, and extend outwards into the Sun's Corona. A typical Prominence extends over many thousands of kilometers as shown in the Fig

Fig: The Solar Prominence



In this project, full-disk H-Alpha solar images are used which are obtained from Kodaikanal Solar Observatory for a period of 2 hours. Image processing techniques such as Enhancement and Segmentation are applied on these images.

FITS

Flexible Image Transport System (FITS) is an open standard defining a digital file format useful for storage, transmission and processing of data, formatted as N-dimensional arrays or tables. FITS is the most commonly used digital file format in astronomy. The FITS standard has special features for scientific data, for example it includes many provisions for describing photometric and spatial calibration information, together with image origin metadata. The major feature of the FITS format is that image metadata is stored in a human-readable ASCII header, so that an interested user can examine the headers to investigate a file of unknown provenance. A FITS file may contain several extensions, and each of these may contain a data object.

DIGITAL IMAGE PROCESSING

Digital image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which the input is an image and the output may be an image or characteristics or features associated with the image. Nowadays, image processing is among rapidly growing technologies. It forms a core research area within engineering

and computer science disciplines too.

Image processing basically includes the following three steps.

- Importing the image via image acquisition tools;
- Analyzing and manipulating the image;
- Output in which result can be altered image or report that is based on image analysis.

LITERATURE SURVEY

In order to understand the project and its purpose thoroughly, a literature survey was performed. The main takeaways from the survey have been included in this chapter.

[1] **Belur Ravindra, Kesavan Prabhu, Komandur Elayaveilli Rangarajan, Bagare P. Shekar, Singh Jagdev, Kemkar Madan Mohan, Paul Lancelot, Koyipurathu Chellappan Thulasidharen, F. Gabriel and Raju Selvendran**, “Full-disk Synoptic Observations of the Chromosphere Using H-Alpha Telescope at the Kodaikanal Observatory” examined in their paper, the installation and the observation of the H-Alpha Solar telescope installed at the KSO on October 7th, 2014. The detailed explanation about the Sun and its chromospheric features and detailed specifications of the telescope, filter unit its installation, observations and calibration of H-Alpha data are reported in this paper.

[2] **Q. Hao, C. Fang, P. F. Chen**, “Developing and Advanced Automated Method for Solar Filament Recognition and its Scientific Application to a Solar Cycle of MLSO H-Alpha data” presented in their paper, a method to automatically detect and recognize the Solar Filament in the H-Alpha full disk observed from Mauna Loa Solar Observatory (MLSO) and to determine properties such as position, area, spine and also evolution of Filaments. The pre-processing techniques are applied to correct the original images and canny edge detection method is used to detect the features and the properties are recognized through morphological operations.

[3] **Q. Hao, C. Fang, W. Cao and P. F. Chen**, “Statistical Analysis of Filament Features based on the H-Alpha Solar images from 1988 to 2013 by Computer Automated Detection Method” presented in their paper, improved version of automated detection applied for MLSO H-Alpha data. The work on full-disk H-Alpha images obtained from the Big-Bare Solar Observatory from 1988 to 2013 is done to determine the information of the filament area, spine length, tilt angle and barb number.

Literature survey has enabled us to understand the importance of the previous work and given useful information to enhance on the present work.

DESIGN METHODOLOGY

H-Alpha solar telescope is used to take full disk images of the Sun in H-Alpha red line whose wavelength is 6563\AA . It has a high spatial resolution and we will be able to study the fine scale features of the Sun. A tunable filter which is called as Lyot filter is used to isolate the H-Alpha spectral line, where filter can be tuned to any locations on strong H-Alpha line. When filter is tuned in steps of 0.4\AA from one wing to core and then to the other wing, the images at these locations on the line profile will be obtained. The Detector system of telescope consists of a CCD camera which has 2048×2048 pixels. The pixel size is about $13.5\mu\text{m}$. The CCD is back illuminated and has 16-bit digitization where the images are stored. The images are captured at the center line, 0.4\AA and 0.8\AA of strong H-Alpha line. The images of the Sun on the line profile will be captured and saved so that we get 60 frames of the Sun images per hour. The flat and the dark images are taken on hour basis which are used for calibration of images. Calibration of image is done by using ImageJ tool.

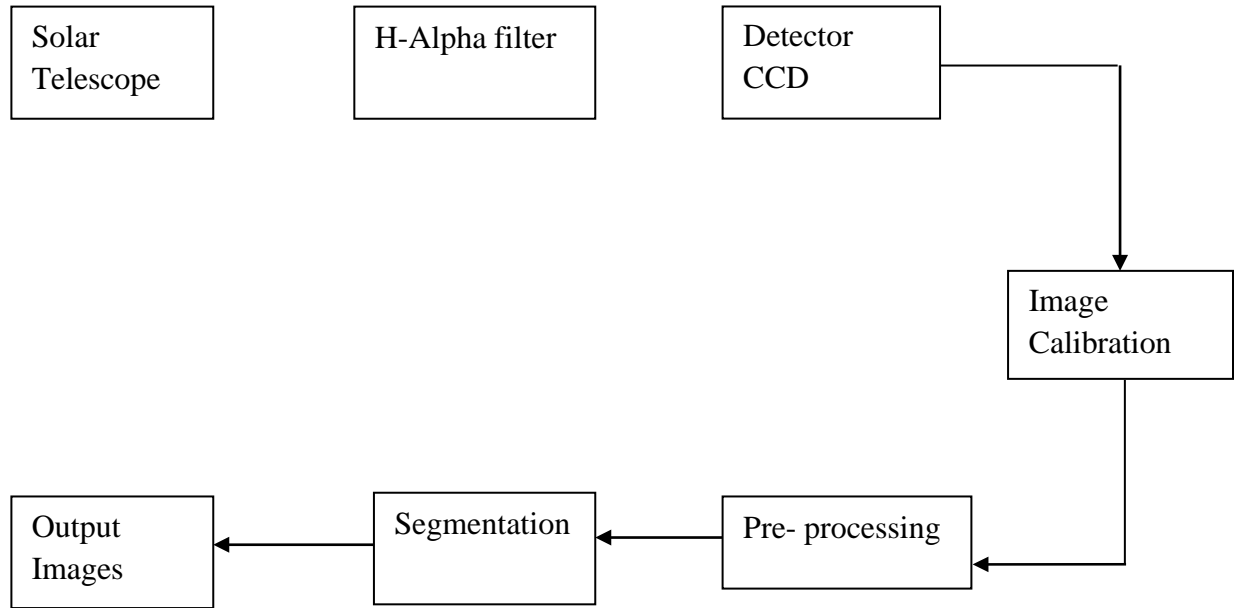


Fig: Observations of H-alpha Images and Extraction of Features

After calibration, the image processing techniques are applied for processing the images. The calibrated images will be pre-processed using enhancement techniques. Different techniques like Log transformation, Contrast stretching, Power law transformation are applied to get the enhanced image so that features will be more clearly visible. The segmentation techniques like edge detection methods are applied on the enhanced images to extract the features of the upper chromospheric layer of the Sun like Filaments and Prominences by which the intensity levels are determined. Registration methods will then be implemented to compare the images at different locations on H-Alpha line profile based on features extracted. The entire layout is as shown in fig

INSTRUMENTATION

H-ALPHA SOLAR TELESCOPE

H-Alpha telescope has been installed at Kodaikanal Solar Observatory on October 7th, 2014 which is as shown in Fig 4.1. The observations made in H-Alpha provide information on the large scale mass motion inside the Filament during its eruption and it is important for modelling solar filament eruption, hence observations made in this wavelength are important for understanding the features of solar flares and coronal mass ejection.



Fig 4.1: H-Alpha Telescope

ground glass prism. The front of the telescope objective is covered with a stepper motor controlled shutter to open and close the lid which prevents dust from entering the telescope system when not in use; one more automated shutter is kept in front of the guider telescope also.

RAW DATA PROCESSING

The H-Alpha images that are obtained from the H-Alpha telescope are the raw images that contain noise and distortion, watermarks due to this we cannot apply image processing techniques on it directly hence we need to calibrate these images before further processing. This calibration is done by using the ImageJ tool.

IMAGEJ TOOL

ImageJ is an open-source public domain software package that was developed by Wayne Rasband, a researcher at the National Institute of Health (NIH), USA, for open source software. Since Image processing is used in many fields, writing code for various tasks including handling of a variety of image file formats and reading/ writing of images becomes a difficult task. Therefore we go for ImageJ software.

ImageJ can help to perform powerful image processing operations and visualize the result. ImageJ supports much functionality that helps us to carry out many image processing tasks visually through its GUI. It provides basic functionalities to display, edit, analyze, process, save and print images of any size (8-bit, 16-bit, 32-bit). It can read many image file formats such as TIFF, GIF, JPEG, BMP, DICOM, FITS, as well as raw image formats. It is platform- independent runs on many operating systems including Windows, Mac OS and Linux.

In this project ImageJ tool is used for calibration of raw images for further processing by using image processing techniques.

FLOW CHART

First three dark images are taken and find the mean of all the three images to get the master dark image. Similarly, take the three flat images and find the mean of all the three images to get master flat image. In order to apply a low-spatial frequency filter to the image polynomial surface fit of an image is performed which can be calculated by using plugin in ImageJ tool then normalize it to get the polynomial surface fit. Then normalize the master flat image and then divide this by normalized polynomial surface fit image to get the master flat surface fit image. Now take the raw image, then subtract the raw image with the master dark image and the result obtained is then divided by the master flat surface fit image to get the calibrated image. This process is done by using the equation 5.1 and the flow is as shown in the Fig 5.2.

calibrated image = raw image – master dark image

$$\frac{\text{raw image} - \text{master dark image}}{\text{master flat surface fit}} \dots (51)$$

- **Raw Image** – It is the image observed directly from the H-Alpha telescope that is stored on CCD detector. The raw image contains water marks and noise.
- **Dark Image** – It is the image obtained by closing the aperture of the main telescope.
- **Flat Image** – It is the image obtained by inserting a diffuser plate into the light path whenever it is necessary.

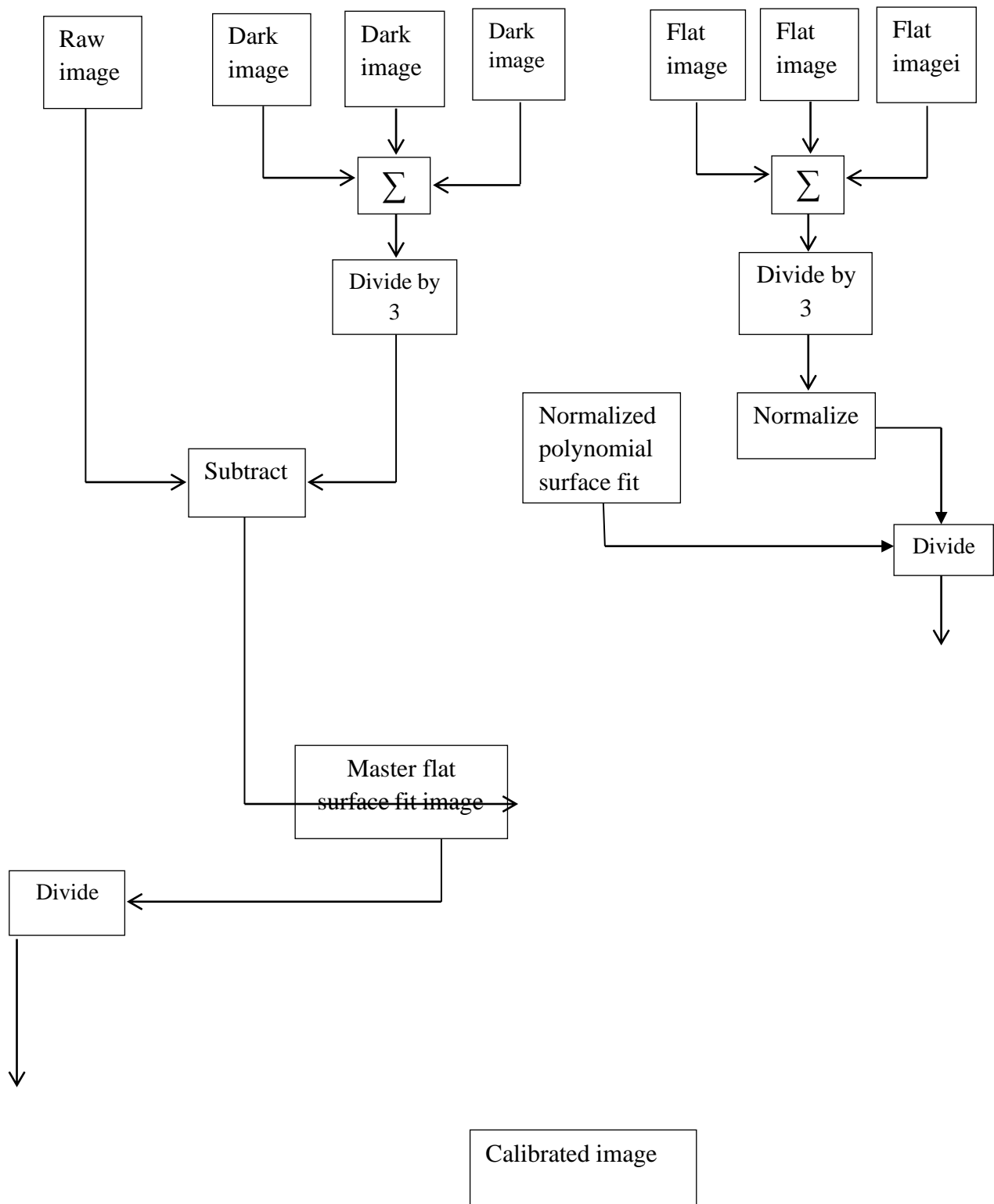


Fig 5.2: Flow chart of Raw Data Processing

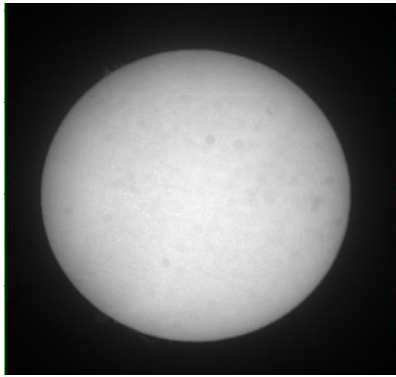


Fig: Raw Image

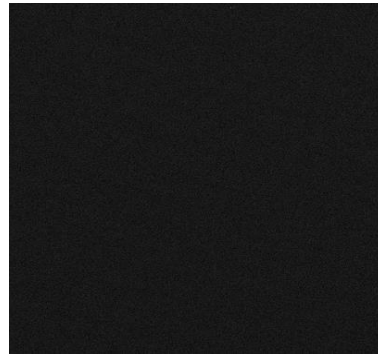


Fig : Dark Image



Fig : Flat Image



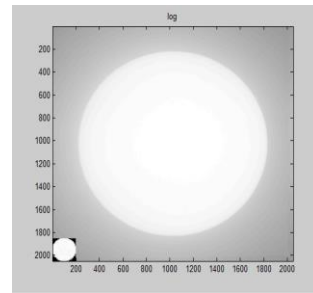
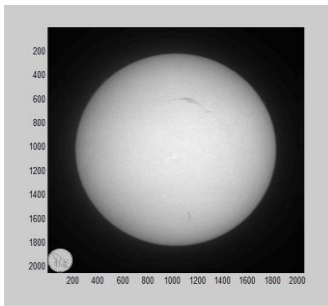
Fig : Calibrated Image

PRE-PROCESSING

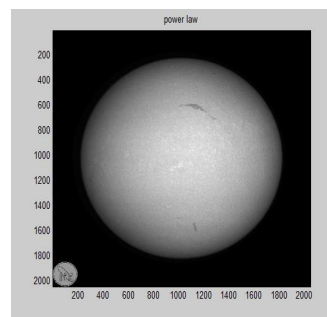
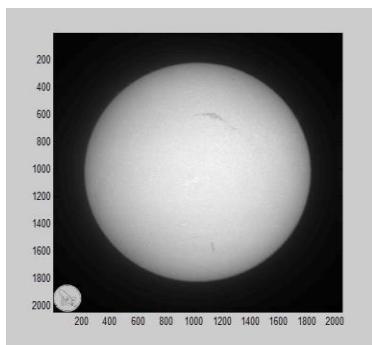
Pre-processing of an image means “preparation” of the sample/image to introduce it to an algorithm for specified task: tracking targets, recognition, feature extraction, etc. It is a common name for operations with images at the lowest level of abstraction where both input and output are intensity images. The main aim of pre-processing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. Image enhancement is one of the pre-processing methods, this aims to improve the quality of the image so that analysis of the image is reliable. The various image enhancement operations are namely:

In this project using the MATLAB tool, enhancement techniques are applied on to the features of the H-Alpha images captured which lies in the upper Chromospheric layer of the Sun. The features of the H-Alpha images include filaments and Chromospheric Networks.

When the Log transformation technique is applied on the original image the resultant image has not enhanced the features which are as shown in the



The Power law transformation was best suitable for the images obtained where it could enhance the features which are as shown in the



MORPHOLOGICAL OPERATIONS

Morphological operations are the non-linear operations in digital image processing related to shape or the morphology of features in an image. These techniques probe an image with a small shape or template called a structuring element. Structuring element is a small binary image with matrix of pixels with the value of zero or one. The structuring element is superimposed at all the possible locations in the image and it is compared with the corresponding neighborhood of pixels.

Some of the fundamental Morphological operations in digital image processing techniques are:

- Dilation
- Erosion

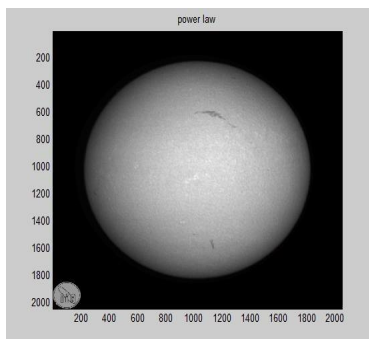


Fig : Power Law Image

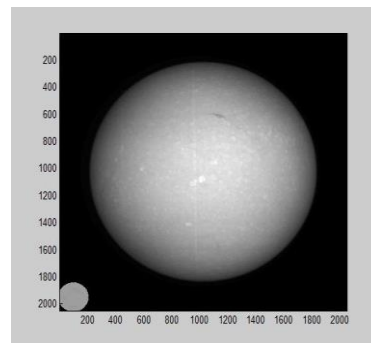


Fig : Dilated Image

EROSION

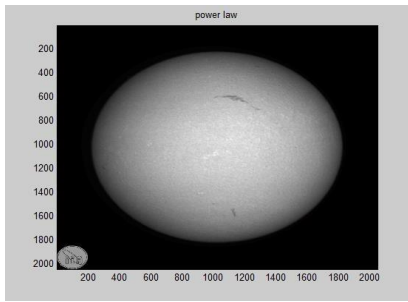


Fig : Power Law Image

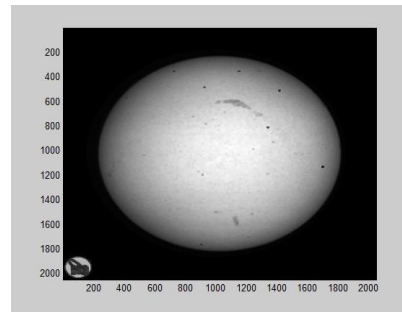


Fig : Eroded Image

SEGMENTATION TECHNIQUES

Most of the segmentation algorithms are based on two basic properties of intensity values: **Discontinuity** and **Similarity**. The 'Discontinuity' approach is to segment the image based on abrupt change in intensity, such as edge in the images. The second approach is based on some predefined criteria upon which images are partitioned.

There are three general approaches to Segmentation, namely Thresholding, Edge-based methods and Region-based methods.

- In Thresholding**, pixels are allocated to categories according to the range of values in which a pixel lies.
- In Edge-based** segmentation, an edge filter is applied to the image, pixels are classified as edge or non-edge depending on the filter output, and pixels which are not separated by an edge are allocated to the same category.
- Finally, **Region-based** segmentation algorithms operate iteratively by grouping together pixels which are neighbors and have similar values and splitting groups of pixels which are dissimilar in value.

WATERSHED TRANSFORMATION

The first step in Watershed transformation is to find gradient image using the sobel operator. Then, MATLAB function watershed () is applied to the gradient image. The result obtained is the over segmentation which is as shown in the Fig. , this can be seen easily as the transform was taken directly on the gradient image. Steps are used to avoid over segmentation are as shown below.

Step 1: find the location of regional minima of the gradient image. This is done using MATLAB function imregionalmin ().

Step 2: obtain the internal markers. Internal markers are found on the original image using the MATLAB function extendedmin (). This assigns minima value as internal markers.

Step 3: obtain the external markers. External markers are obtained by finding watershed transform of distance transform of original image. Where ever output is zero, they are masked as external markers.

Step 4: modify the gradient image. Gradient image is modified based on the location of internal and external markers. MATLAB function imimposemin () modifies the image using morphological reconstruction so that regional minima are present only when there is a internal or external marker.

Step 5: Watershed transform of modified gradient image is taken and boundaries obtained by Watershed transform is made white. All major segments are found. Thus, over segmentation is avoided by using internal and external markers and restricting the minima to only few. The final segmented output is as shown in the Fig 8.13.

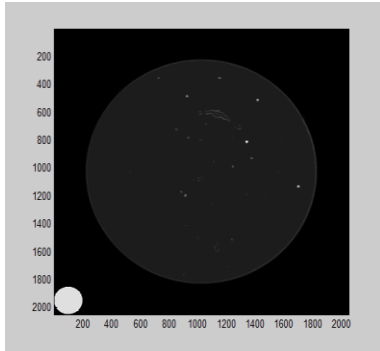


Fig : Filled Image

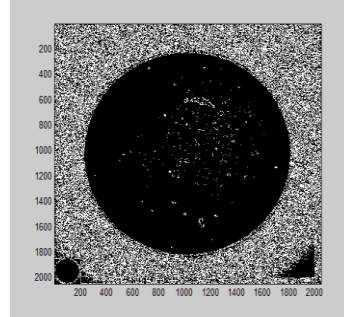


Fig : Over Segmented Image

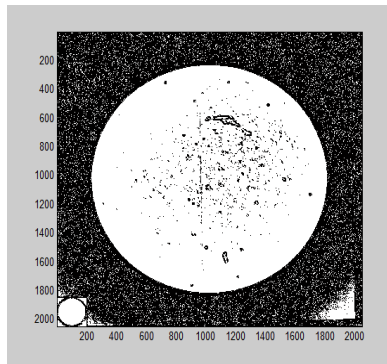


Fig : Segmented Image



Fig:Filament1



Fig:Filament1 Fig: Filament2

OBSERVATIONS

During the visit to Kodaikanal Solar Observatory on January 2018, the H-Alpha solar telescope was used to obtain the time sequence of full disk images in H-Alpha line from January 22nd to 27th, 2018. Since there was no solar activity observed during the visit to Kodaikanal Solar Observatory, the images observed on 8th January 2018 are used for the feature extraction. In this project two filaments are studied which are as shown in Fig 8.14 and Fig 8.15 observed on January 8th, 2018 for two hours with the time resolution of two minutes cadence. Quiet Sun at the center of the solar disk was observed for two hours with the time interval of two minutes per frame from January 22nd to 27th, 2018 at the wavelength locations of 0.0Å, 0.4Å and 0.8Å. In this study the intensity changes in the filaments and in the quiet Sun regions are studied and compared.

INTENSITY VARIATIONS OF FILAMENTS

Intensity vs. time graphs are plotted for filament1 and filament2 which are observed for the duration of two hours with the resolution of two minutes cadence on the segmented images. Intensity variations are observed for both the filaments due to the magnetic activities on the solar atmosphere and are plotted in Fig

Table: Intensity values of Filament1

Time in min	Intensity1	Intensity2	Intensity3	Average
1	33264	29689	30594	31182
2	31385	28858	30910	30384
3	31425	30567	31157	31050
4	32871	30911	32291	32024
5	29835	32873	31316	31341
6	34251	31258	31354	32288
7	30141	34304	33208	32551
8	32022	30047	33736	31935
9	28991	33118	32377	31495
10	31034	30685	33602	31774
11	31144	33566	29058	31256
12	28742	30214	30454	29803
13	28569	31522	31059	30383
14	31042	29169	31087	30433
15	28453	27779	32491	29574
16	29347	30960	32634	30980
17	31939	28838	30639	30472
18	30660	31052	31933	31215
19	29702	31332	28775	29936
20	28147	31051	29016	29404
21	28735	29181	31722	29879

22	27765	26989	28209	27654
23	26822	29838	30252	28971
24	27334	30824	29196	29118
25	30640	31768	27110	29839
26	29379	31117	30339	30278
27	30707	30004	32450	31054
28	31430	29201	32011	30880
29	28163	31617	30186	29989
30	30613	32180	29903	30899
31	30514	31214	29776	30501
32	28772	30513	31216	30167
33	30727	30230	31839	30932
34	29524	31416	31737	30892
35	31489	28739	32331	30853
36	29403	31238	32759	31133
37	31630	28411	32856	30966
38	29129	32344	32978	31484
39	33424	28497	32736	31552
40	28671	31093	31293	30352
41	29633	31675	31941	31083
42	30168	32143	32018	31443
43	31599	28352	31478	30476
44	30692	31360	33418	31823
45	28437	31050	33134	30874
46	29366	31371	33679	31472

Table: Intensity values of Filament2

Time in min	Intensity1	Intensity2	Intensity3	Average
1	28842	28044	27380	28089
2	29243	28202	27324	28256
3	29206	28439	27901	28515
4	29807	28341	28414	28854
5	29089	28111	27365	28188
6	29912	27716	28789	28806

7	29945	28172	27313	28477
8	30661	29185	27582	29143
9	30130	29273	28120	29174
10	29660	29922	27322	28968
11	29834	29041	27072	28646
12	28510	27405	27601	27839
13	26770	27685	26971	27142
14	28163	27541	26693	27436
15	29350	28661	26678	28230
16	29140	27419	27178	27912
17	27863	27166	27427	27485
18	28308	26966	26785	27353

19	28816	28117	27317	28083
20	29955	28305	27440	28567
21	29867	28111	28597	28858
22	29389	28086	27733	28403
23	29324	28549	28134	28336
24	29308	28710	28345	28817

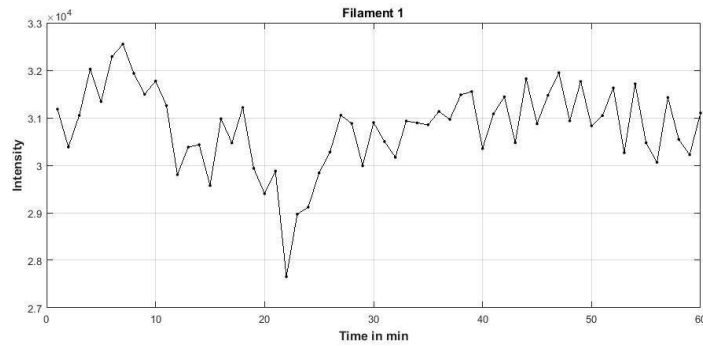
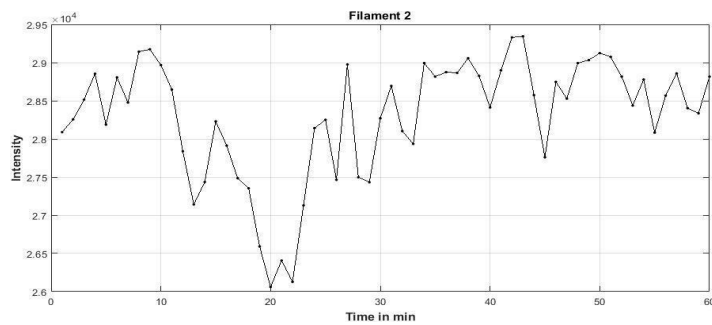


Fig: Intensity variations in filament1

Fig: Intensity variations in filament2



INTENSITY VARIATIONS IN THE QUIET SUN REGIONS AT THE CENTER OF THE SOLAR DISK

Time series analysis has been done for the images which are observed for the duration of two hours on the strong H-alpha line profile at 0.0Å, 0.4Å and 0.8Å with the time resolution taken as two minutes cadence obtained on January 27th, 2018 using H-Alpha Solar telescope at Kodaikanal Solar Observatory. Where 0.0Å, 0.4Å and 0.8Å represents the different levels on the solar atmosphere. Since the Sun is now with end of the solar cycle minima, the Sun is quiet and not many activities are observed. Intensity variations are determined at the centre of the solar disk and graphs are plotted with respect to time. Intensities at different levels of line profile (0.0Å, 0.4Å and 0.8Å) are inter compared and is as shown in the Fig 10.1. From the Fig 9.1, 9.2 and 10.1 it was found that filaments show a very large intensity fluctuations compared to quiet Sun regions observed in H-Alpha images. It is noticed that filaments are active regions which help to contribute and give rise to solar flare.

Table : Intensity values at 0.0Å

Time in min	Intensity1	Intensity2	Intensity3	Intensity4	Intensity5	Average
1	3.16E+04	3.20E+04	3.18E+04	3.19E+04	3.17E+04	3.18E+04
2	3.14E+04	3.19E+04	3.25E+04	3.25E+04	3.14E+04	3.19E+04
3	3.21E+04	3.26E+04	3.29E+04	3.26E+04	3.22E+04	3.25E+04
4	3.21E+04	3.25E+04	3.35E+04	3.31E+04	3.33E+04	3.29E+04
5	3.30E+04	3.33E+04	3.33E+04	3.40E+04	3.26E+04	3.32E+04
6	3.35E+04	3.36E+04	3.41E+04	3.34E+04	3.33E+04	3.36E+04
7	3.35E+04	3.42E+04	3.44E+04	3.43E+04	3.38E+04	3.40E+04
8	3.32E+04	3.37E+04	3.42E+04	3.42E+04	3.41E+04	3.39E+04
9	3.53E+04	3.41E+04	3.53E+04	3.45E+04	3.42E+04	3.47E+04
10	3.44E+04	3.50E+04	3.55E+04	3.54E+04	3.54E+04	3.51E+04
11	3.46E+04	3.43E+04	3.56E+04	3.43E+04	3.53E+04	3.48E+04
12	3.49E+04	3.52E+04	3.60E+04	3.56E+04	3.55E+04	3.54E+04
13	3.49E+04	3.48E+04	3.62E+04	3.57E+04	3.54E+04	3.54E+04
14	3.72E+04	3.54E+04	3.57E+04	3.63E+04	3.60E+04	3.61E+04
15	3.56E+04	3.52E+04	3.59E+04	3.62E+04	3.57E+04	3.57E+04
16	3.82E+04	3.83E+04	3.78E+04	3.83E+04	3.82E+04	3.82E+04
17	3.85E+04	3.77E+04	3.81E+04	3.87E+04	3.83E+04	3.83E+04

18	3.91E+04	3.80E+04	3.86E+04	3.81E+04	3.86E+04	3.85E+04
19	3.87E+04	3.85E+04	3.87E+04	3.89E+04	3.88E+04	3.87E+04
20	3.74E+04	3.81E+04	3.80E+04	3.85E+04	3.77E+04	3.79E+04
21	3.78E+04	3.85E+04	3.84E+04	3.86E+04	3.89E+04	3.84E+04
22	3.88E+04	3.83E+04	3.84E+04	3.88E+04	3.86E+04	3.86E+04
23	3.89E+04	3.81E+04	3.91E+04	3.93E+04	3.91E+04	3.89E+04
24	3.91E+04	3.84E+04	3.89E+04	3.95E+04	3.84E+04	3.89E+04
25	3.90E+04	3.83E+04	3.89E+04	3.94E+04	3.82E+04	3.88E+04
26	3.82E+04	3.85E+04	3.92E+04	3.99E+04	3.90E+04	3.90E+04
27	3.87E+04	3.89E+04	3.93E+04	3.92E+04	3.84E+04	3.89E+04
28	3.93E+04	3.93E+04	3.92E+04	3.95E+04	3.93E+04	3.93E+04
29	3.97E+04	3.85E+04	3.91E+04	3.98E+03	3.96E+04	3.22E+04
30	3.96E+04	3.89E+04	3.96E+04	3.97E+04	3.82E+04	3.92E+04
31	3.90E+04	3.74E+04	3.89E+04	3.90E+04	3.76E+04	3.84E+04
32	3.76E+04	3.80E+04	3.92E+04	3.88E+04	3.84E+04	3.84E+04
33	3.76E+04	3.84E+04	3.92E+04	3.82E+04	3.76E+04	3.82E+04
34	3.77E+04	3.80E+04	3.81E+04	3.82E+04	3.80E+04	3.80E+04
35	3.77E+04	3.78E+04	3.87E+04	3.85E+04	3.86E+04	3.83E+04
36	3.70E+04	3.86E+04	3.85E+04	3.87E+04	3.88E+04	3.83E+04
37	3.89E+04	3.78E+04	3.88E+04	3.93E+04	3.78E+04	3.85E+04
38	3.91E+04	3.84E+04	3.81E+04	3.92E+04	3.91E+04	3.87E+04
39	3.84E+04	3.86E+04	3.95E+04	3.91E+04	3.88E+04	3.89E+04
40	3.82E+04	3.80E+04	3.91E+04	3.95E+04	3.93E+04	3.88E+04
41	3.98E+04	3.92E+04	3.89E+04	3.95E+04	3.91E+04	3.93E+04
42	3.89E+04	3.91E+04	3.89E+04	3.97E+04	3.94E+04	3.92E+04
43	3.93E+04	3.92E+04	3.96E+04	3.96E+04	3.90E+04	3.93E+04
44	3.81E+04	3.93E+04	3.87E+04	3.95E+04	3.94E+04	3.90E+04
45	3.99E+04	3.91E+04	3.96E+04	3.95E+04	3.90E+04	3.94E+04
46	3.93E+04	3.92E+04	3.89E+04	3.93E+04	3.90E+04	3.92E+04
47	3.91E+04	3.92E+04	3.92E+04	4.02E+04	3.93E+04	3.94E+04
48	3.95E+04	3.93E+04	4.01E+04	3.93E+04	3.97E+04	3.95E+04
49	4.00E+04	3.87E+04	4.02E+04	4.01E+04	3.94E+04	3.97E+04
50	3.83E+04	3.89E+04	3.99E+04	3.95E+04	3.98E+04	3.93E+04
51	3.96E+04	3.92E+04	4.03E+04	3.93E+04	3.94E+04	3.96E+04
52	3.98E+04	3.87E+04	4.02E+04	4.00E+04	3.93E+04	3.96E+04
53	4.05E+04	3.94E+04	3.95E+04	4.02E+04	3.94E+04	3.98E+04

54	3.99E+04	3.90E+04	3.93E+04	3.96E+04	3.94E+04	3.94E+04
55	3.92E+04	3.93E+04	4.04E+04	4.02E+04	4.07E+04	4.00E+04
56	3.94E+04	3.96E+04	3.98E+03	4.04E+04	4.05E+04	3.28E+04
57	4.04E+04	3.94E+04	3.96E+04	3.97E+04	3.94E+04	3.97E+04
58	3.94E+04	3.95E+04	3.98E+04	3.98E+04	3.99E+04	3.97E+04
59	3.86E+04	3.87E+04	3.97E+04	4.02E+04	3.99E+04	3.94E+04
60	4.13E+04	3.95E+04	3.95E+04	4.07E+04	3.97E+04	4.01E+04

Table: Intensity values at 0.4Å

Time in min	Intensity1	Intensity2	Intensity3	Intensity4	Intensity5	Average
1	4.04E+04	3.92E+04	4.01E+04	4.08E+04	4.03E+04	4.01E+04
2	4.12E+04	4.01E+04	4.03E+04	4.06E+04	4.08E+04	4.06E+04
3	4.08E+04	4.05E+04	4.08E+04	4.13E+04	4.03E+04	4.07E+04
4	4.07E+04	4.00E+04	4.05E+04	4.01E+04	3.87E+04	4.00E+04
5	4.18E+04	3.94E+04	4.08E+04	4.03E+04	3.99E+04	4.04E+04
6	4.11E+04	4.01E+04	4.01E+04	4.10E+04	4.00E+04	4.05E+04
7	4.12E+04	3.95E+04	4.05E+04	4.00E+04	3.99E+04	4.02E+04
8	4.05E+04	3.99E+04	4.08E+04	4.13E+04	4.03E+04	4.05E+04
9	4.13E+04	3.97E+04	4.02E+04	4.11E+04	3.95E+04	4.04E+04
10	4.13E+04	3.99E+04	4.06E+04	4.07E+04	4.10E+04	4.07E+04
11	4.05E+04	4.04E+04	4.05E+04	4.09E+04	4.07E+04	4.06E+04
12	4.09E+04	4.03E+04	4.01E+04	4.06E+04	4.08E+04	4.05E+04
13	4.16E+04	4.04E+04	3.99E+04	4.04E+04	4.11E+04	4.07E+04
14	4.10E+04	4.06E+04	4.10E+04	4.08E+04	4.02E+04	4.07E+04
15	4.04E+04	4.03E+04	4.07E+04	4.09E+04	4.05E+04	4.06E+04
16	4.10E+04	4.01E+04	4.06E+04	4.09E+04	4.06E+04	4.06E+04
17	3.99E+04	4.05E+04	4.04E+04	4.18E+04	3.97E+04	4.04E+04
18	4.01E+04	4.00E+04	4.06E+04	4.12E+04	4.11E+04	4.06E+04
19	4.19E+04	4.07E+04	4.09E+04	4.08E+04	4.06E+04	4.10E+04
20	4.16E+04	4.02E+04	4.00E+04	4.11E+04	4.11E+04	4.08E+04
21	4.04E+04	3.99E+04	4.06E+04	4.13E+04	3.97E+04	4.04E+04
22	4.19E+04	4.06E+04	4.11E+04	4.15E+04	4.14E+04	4.13E+04
23	4.06E+04	4.06E+04	4.06E+04	4.07E+04	4.15E+04	4.08E+04
24	4.11E+04	4.04E+04	4.09E+04	4.15E+04	4.15E+04	4.11E+04
25	4.19E+04	4.03E+04	4.11E+04	4.09E+04	4.02E+04	4.09E+04

Table: Intensity values at 0.8Å

Time in min	Intensity1	Intensity2	Intensity3	Intensity4	Intensity5	Average
1	4.61E+04	4.62E+04	4.66E+04	4.68E+04	4.55E+04	4.62E+04
2	4.66E+04	4.51E+04	4.65E+04	4.68E+04	4.61E+04	4.62E+04
3	4.68E+04	4.59E+04	4.72E+04	4.60E+04	4.66E+04	4.65E+04
4	4.56E+04	4.56E+04	4.64E+04	4.67E+04	4.50E+04	4.59E+04
5	4.64E+04	4.58E+04	4.34E+04	4.44E+04	4.53E+04	4.51E+04
6	4.75E+04	4.52E+04	4.40E+04	4.75E+04	4.63E+04	4.61E+04
7	4.59E+04	4.49E+04	4.54E+04	4.47E+04	4.59E+04	4.54E+04
8	4.70E+04	4.61E+04	4.66E+04	4.64E+04	4.56E+04	4.63E+04
9	4.76E+04	4.72E+04	4.61E+04	4.67E+04	4.83E+04	4.72E+04
10	4.66E+04	4.66E+04	4.58E+04	4.54E+04	4.63E+04	4.61E+04
11	4.56E+04	4.54E+04	4.62E+04	4.81E+04	4.68E+04	4.64E+04
12	4.71E+04	4.26E+04	4.53E+04	4.58E+04	4.55E+04	4.52E+04
13	4.63E+04	4.49E+04	4.70E+04	4.74E+04	4.61E+04	4.63E+04
14	4.78E+04	4.70E+04	4.85E+04	4.76E+04	4.59E+04	4.73E+04
15	4.67E+04	4.53E+04	4.68E+04	4.65E+04	4.49E+04	4.60E+04
16	4.61E+04	4.49E+04	4.57E+04	4.55E+04	4.59E+04	4.56E+04
17	4.68E+04	4.59E+04	4.56E+04	4.59E+04	4.70E+04	4.62E+04
18	4.52E+04	4.34E+04	4.57E+04	4.43E+04	4.72E+04	4.52E+04
19	4.73E+04	4.65E+04	4.72E+04	4.84E+04	4.54E+04	4.70E+04
20	4.86E+04	4.46E+04	4.83E+04	4.63E+04	4.55E+04	4.66E+04
21	4.49E+04	4.73E+04	4.59E+04	4.88E+04	4.51E+04	4.64E+04
22	4.68E+04	4.60E+04	4.55E+04	4.66E+04	4.65E+04	4.63E+04
23	4.49E+04	4.46E+04	4.61E+04	4.61E+04	4.55E+04	4.55E+04
24	4.69E+04	4.63E+04	4.49E+04	4.47E+04	4.59E+04	4.57E+04
25	4.65E+04	4.52E+04	4.63E+04	4.78E+04	4.60E+04	4.64E+04
26	4.59E+04	4.69E+04	4.65E+04	4.52E+04	4.49E+04	4.59E+04
27	4.74E+04	4.59E+04	4.72E+04	4.59E+04	4.67E+04	4.66E+04
28	4.61E+04	4.44E+04	4.64E+04	4.56E+04	4.47E+04	4.54E+04
29	4.64E+04	4.58E+04	4.66E+04	4.71E+04	4.50E+04	4.62E+04
30	4.64E+04	4.51E+04	4.50E+04	4.65E+04	4.50E+04	4.56E+04
31	4.67E+04	4.45E+04	4.51E+04	4.64E+04	4.68E+04	4.59E+04
32	4.86E+04	4.67E+04	4.62E+04	4.68E+04	4.71E+04	4.71E+04
33	4.72E+04	4.65E+04	4.73E+04	4.65E+04	4.75E+04	4.70E+04
34	4.70E+04	4.57E+04	4.68E+04	4.62E+04	4.55E+04	4.62E+04

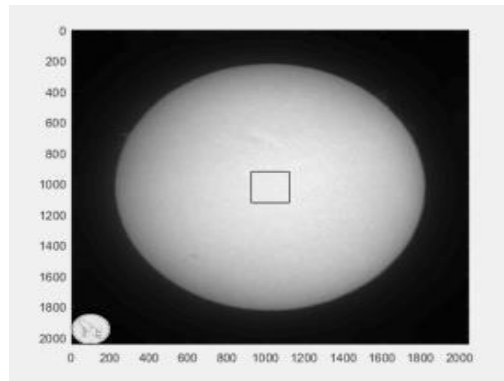


Fig: Quiet Sun region taken at the center of the disk

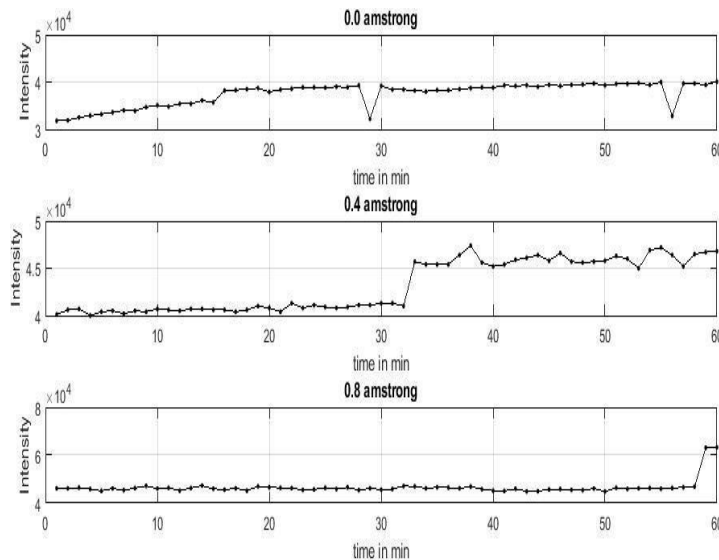


Fig: Intensity vs.time plot at the centre of the solar disk

SULTS AND CONCLUSIONS

A thorough study and working of $H\alpha$ telescope of Kodaikanal Solar Observatory was done by the group. The telescope is used to obtain the images of the Sun in $H\alpha$ line. The $H\alpha$ images of the Sun are obtained at different locations of line profile by tuning the filter. The digital image processing techniques like enhancement and segmentation are applied on the images in order to detect and extract the features (dark filaments, Chromospheric networks). Then the intensity variations with respect time are plotted for filaments. The time series analysis was done on the $H\alpha$ images taken at different locations (0.0\AA , 0.4\AA , 0.8\AA) on the line profile which was observed on January 27th, 2018 for two hours at the time interval of two minutes per frame and derived the intensity v/s time plot. The evolution of filament for a period of four months (January-April) in the year 2016 has been observed which give rise to a Solar flare. These Solar flares emit very high energy radiation particles which affects the satellite communication, earth climate, and space weather. This research would help to extract and understand the various features observed in medical images, satellite images, etc.

FUTURE SCOPE

1. The power spectrum analysis will be carried out on the time series of quiet regions and filaments to find the period of intensity oscillations associated with these regions and to inter-compare the observed periods seen at the different locations of the H-Alpha line profile from its center wavelength.
2. Since it is known from the evolution of filaments that they are responsible for the Solar flare, which releases high energy particles, by observing the time series during the Solar flare, the amount energy released will be estimated.
3. Study of solar flare and its impacts on satellite communication and on Earth's climate and space weather will be carried out.
4. It is proposed to apply the image processing tools on the medical images, satellite images to extract the finer scale features, which would help to understand and diagnose the diseases further follow up and treatment, etc.

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