Analysis Tool using Running-Difference Polar Representation of SDO Big Data

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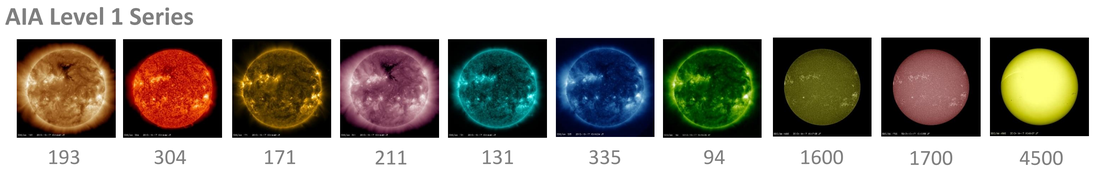
Abstract.

We have developed a software tool to detect coronal features automatically using Solar Dynamics Observatory (SDO) data by polar representation. We focused on the off-limb solar features which shows vivid configuration of coronal features with height. We used EUV imaging data obtained by 171 channel of Atmospheric Imaging Assembly (AIA) on board SDO. The software consists of three parts: collecting file list, processing FITS files, and creating running-difference polar representation images. We have applied the contrast enhancement method using sigmoid function and histogram equalization. Based on the output, we will implement the catalog of coronal features, a search engine and viewing service. In order to handle huge amount of SDO data, it is necessary to parallelize computing process. We expect the algorithm of this tool to be used for detection of Coronal Mass Ejections (CMEs) using coronagraph imaging data.

Introduction

Coronal loops are common structure of the low corona in the solar atmosphere. Hence, the study on the coronal loops can improve the understanding of coronal physics. SDO EUV imaging data have revealed various characteristics of coronal loop structures in size, lifetime, evolution, and so on. We have developed a software tool to automatically detect coronal features such as coronal loops using EUV imaging data obtained by SDO AIA 171 channel. The AIA 171 channel exhibits vivid configuration of off-limb coronal feature with height. For this work, we used 12-seconds cadence data with FITS format from Korea Data Center(KDC) for SDO. KDC for SDO have archived and provided AIA and Helioseismic and Magnetic Imager (HMI) through cooperation with Stanford University. AIA and HMI produce huge amount of data, 1.5 TB per day.

AIA Level 1 Series



Website : http://sdo.kasi.re.kr

Methodology

We have selected to detect coronal loops among several coronal features. We used running-difference images to detect the morphological changes of coronal loops and polar representation images to measure the height and width of coronal loops.
There are three parts involved in the tool. The first is collecting file list, the second is processing FITS files and the third is to make running-difference images and polar representation images.

1. Collecting file list
   This tool needs input parameter value which is date (yyyymmdd) to collect file list. The module makes the directory structure using input value because SDO AIA data are divided into wavelength, year and date. The module accesses the directories and figures out file number and file names. The number of SDO AIA 171 fits files is about 7,000 per day.

2. Processing FITS files
   - Instrument : AIA Level 1
   - FITS image handling library : CFITSIO v3.370 64bit
   - FITS image uncompression program : funpack
   - Data scaling Formula (from SolarSoft)

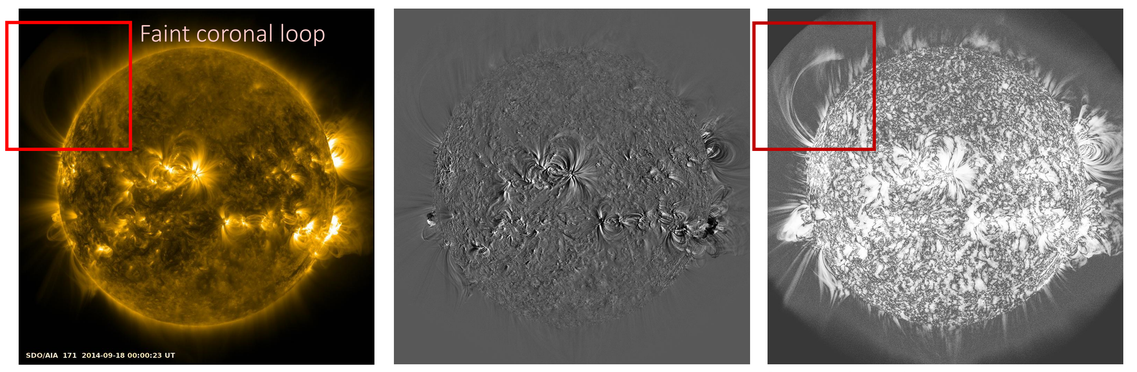
Wavelength [Å]	Data scaling Formula	Minimum	Maximum
94	sqrt(img * 4.99803 / exp)	1.5	50
131	log10(img * 6.99685 / exp)	7	1200
171	sqrt(img * 4.99803/ exp)	10	6000
193	log10(img * 2.99950/ exp)	120	6000
211	log10(img * 4.99801/ exp)	30	13000
304	log10(img * 4.99941/ exp)	25	2000
335	log10(img * 6.99734/ exp)	3.5	1000

※ img: data value, exp: exposure time

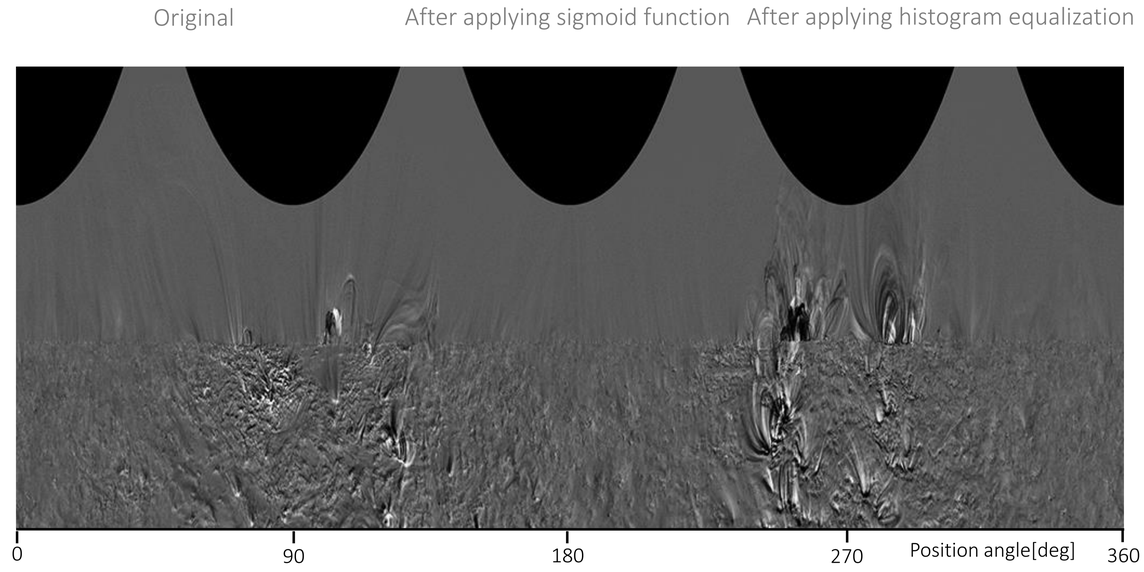
3. Running-difference and polar representation
   Coronal loops stay generally hours and days. We set the difference cadence to 1 hour but it could be changed several hours for faint features. An important step in the procedure is contrast enhancement using Sigmoid function and Histogram equalization.

	Sigmoid Function	Histogram Equalization
Implementation	$f(x) = \frac{1}{1 + e^{-tx}}$ $(-1 \le x \le 1)$	$p_x(i) = p(x = i) = \frac{n_i}{n}$ $(0 \le i \le L)$
parameters	The contrast factor ***t***	The total number of gray levels in the image : **L** (typically 256) The total number of pixels: **n**

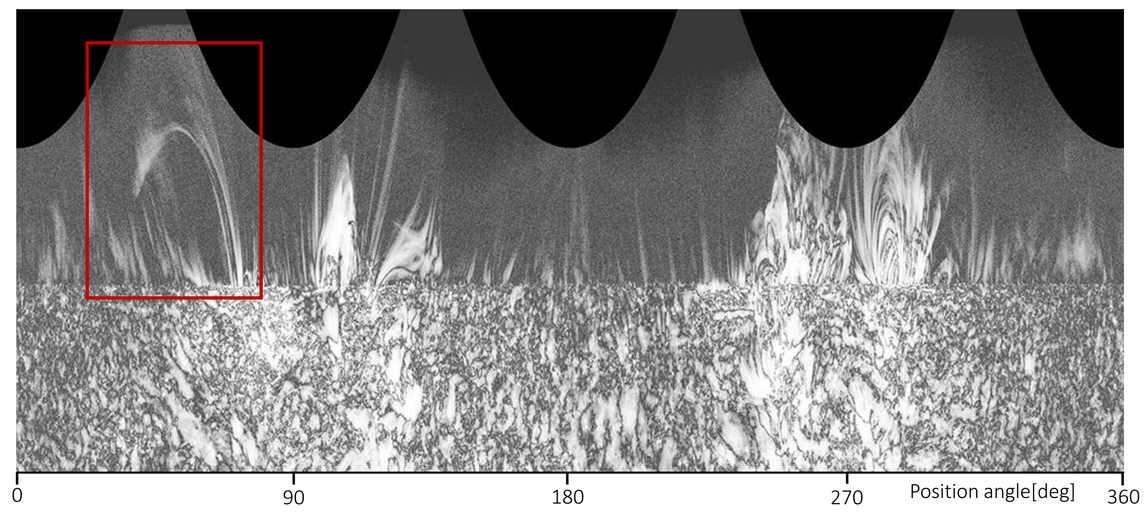
Result



Original | After applying sigmoid function | After applying histogram equalization



Polar representation: 1-hr cadence difference & applying sigmoid function



Polar representation: 5-hr cadence difference & applying histogram equalization

Conclusion and Future Work

We have implemented an analysis tool to detect coronal features automatically. This software handles 12-second cadence AIA FITS files from KDC for SDO. It is better to use absolute difference values and histogram equalization to enhance the contrast of output. We will make the coronal feature catalog, search engine and viewing service. Also parallelized computing process will be applied for creating running difference and polar representation images because SDO data are so huge size. We expect that the algorithm of this tool would be Coronal Mass Ejections (CMEs) detecting using coronagraph data.

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