Flare detection from discrete Fourier transforms of SJIs

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Poster

4. Eruptions in the solar atmosphere

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We present a new method to detect solar flares based on the IRIS SJI. Usually the detection is made based on intensity cutoffs, but this can easily result in the detection of small energetic events without any actual flare appearing. Our method reduces the false detections of flares by taking in consideration the specific pattern of flares.
By using sequences of 10 consecutive SJIs, we place importance on the temporal component of flares. These short videos are parcelled in small blocks of size 20×20 pixels to analyse the local variations of the frequencies by looking at the variance of the discrete Fourier transform (DCT) of the signal. Each frame is also pre-passed through the 2-dimensional DCT in order to be well aligned. We then found parameters to distinguish the flare sequences from the non-flare sequences.
For now we have a 99% detection accuracy on 500 sequences of 10 consecutive frames for 1400A SJI, with 1 sequence missed and no sequence with false detection.
To conclude, we would like to present results of our method in a E-Poster to show videos of results. We use some handcrafted supervised machine learning techniques to show that it is possible to accurately detect flares from the SJI with this method. Firstly, it will allow us to create a complete automatic list of flares in the IRIS database. Secondly, our tool will also help us analyzing the flares with more machine learning techniques. Our work is supported by the Swiss National Science Fondation (SNF) National Research Program 75 "Big Data" and we want to acknowledge LMSAL for the access to the IRIS database.

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Overview

- New method to **detect solar flares** based on the IRIS slit-jaw images (**SJIs**)
- Reduces the false detections of flares:
  - **Time component** is important
  - Extraction of their **specific patterns**
- **99% detection accuracy on 500 sequences (videos) of 10 consecutive frames for 1400Å SJI frames**
- **Data processing poster** ⟶ **to show results**
- Goal: **the creation of a large labeled IRIS dataset of flares**
- Why: Doing more **machine learning analysis** of flares
- **Useful tools :** preprocessing and analysis of IRIS SJIs

Why SJIs ?

- Because it is where astrophysicists have less information

- **With Machine learning, we wish to provide more information to the full SJI field of view**

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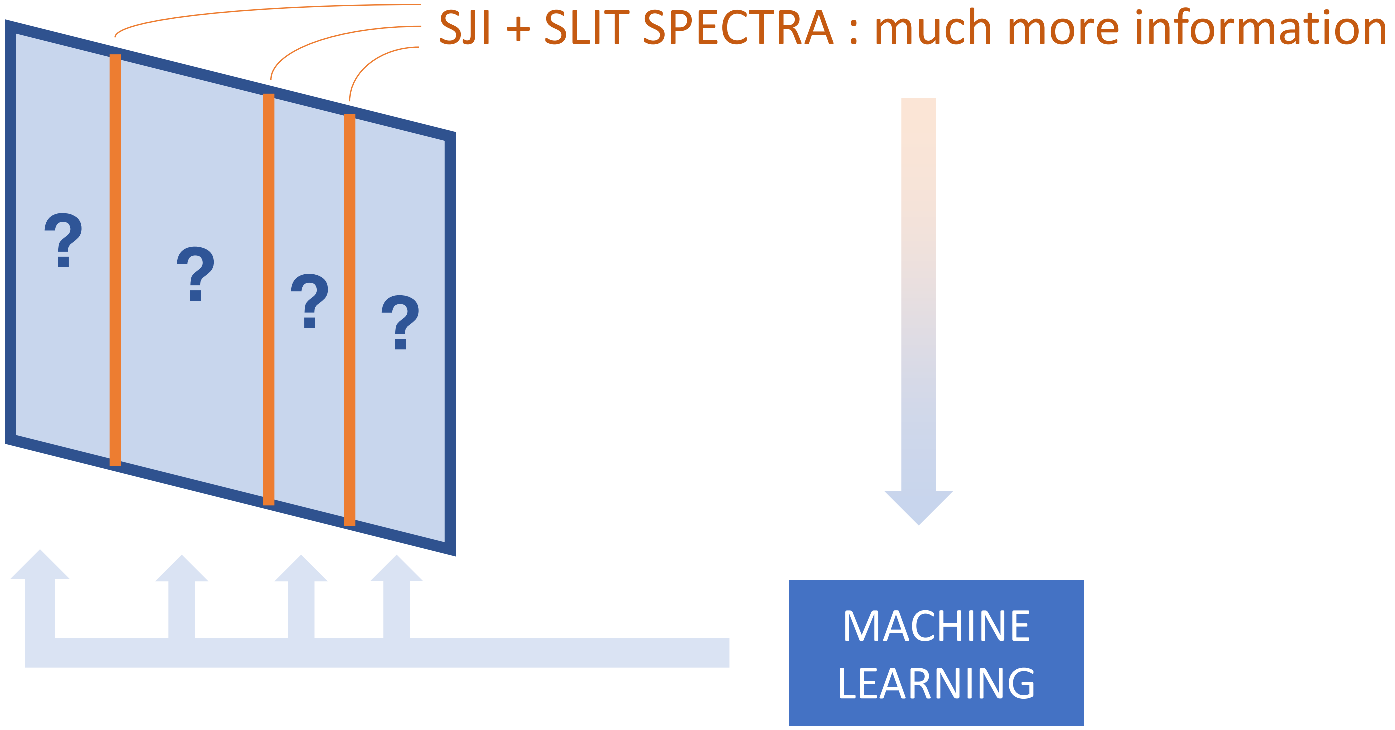
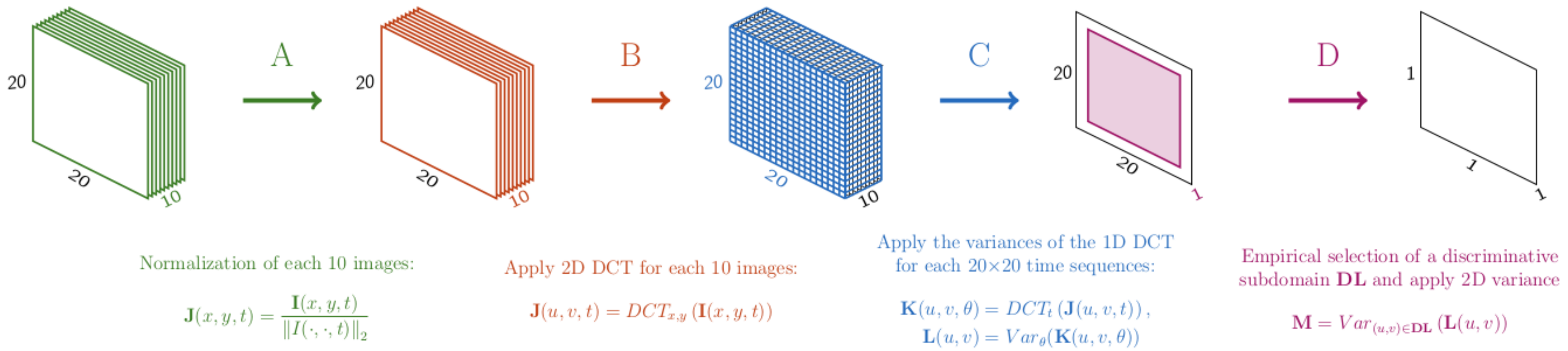


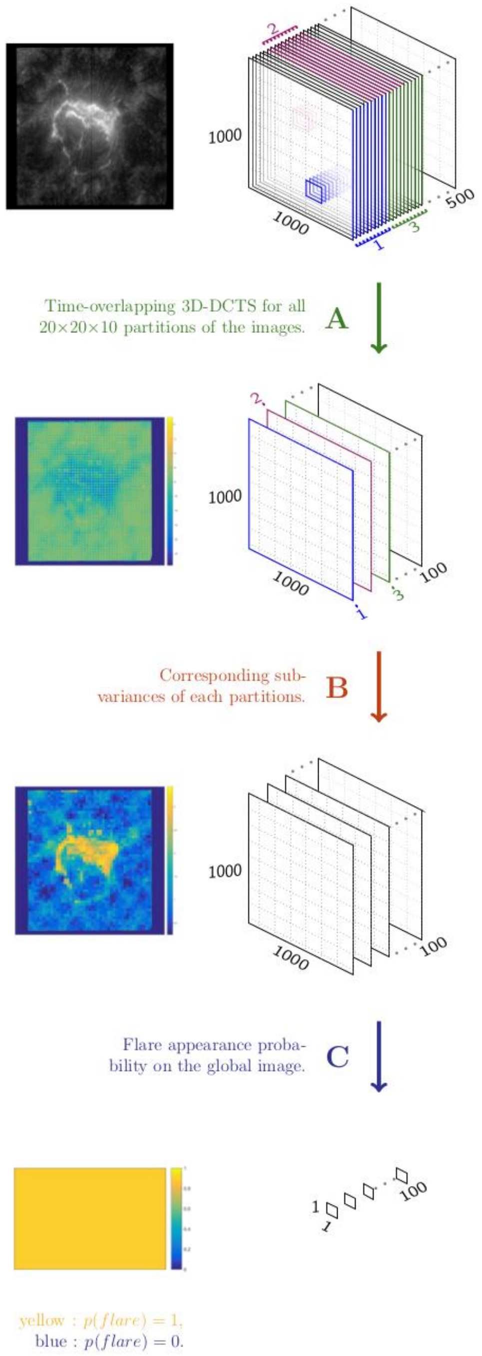
- **With Machine learning, we wish to provide more information to the full SJI field of view**

Not going into details!

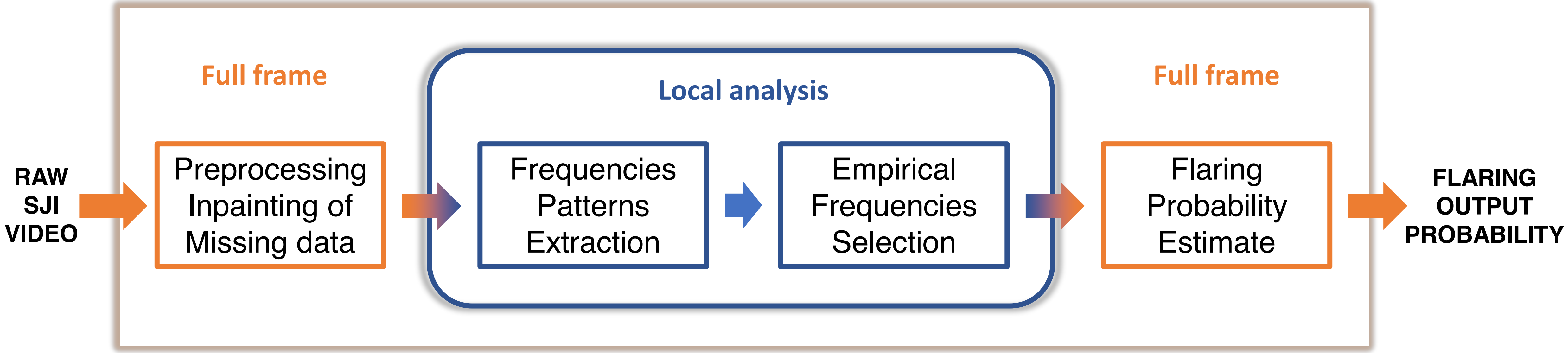


$$DCT_{x,y}(\mathbf{I}(x,y,t)) = \frac{c(u)c(v)}{\sqrt{XY}} \sum_{\substack{x=0\\y=0}}^{\substack{X-1\\Y-1}} \mathbf{I}(x,y,t) f_X(x,u) f_Y(y,v)$$

$$\text{where } f_X(x,u) = \cos\left(\frac{(2x+1)u\pi}{2X}\right)$$



Our approach

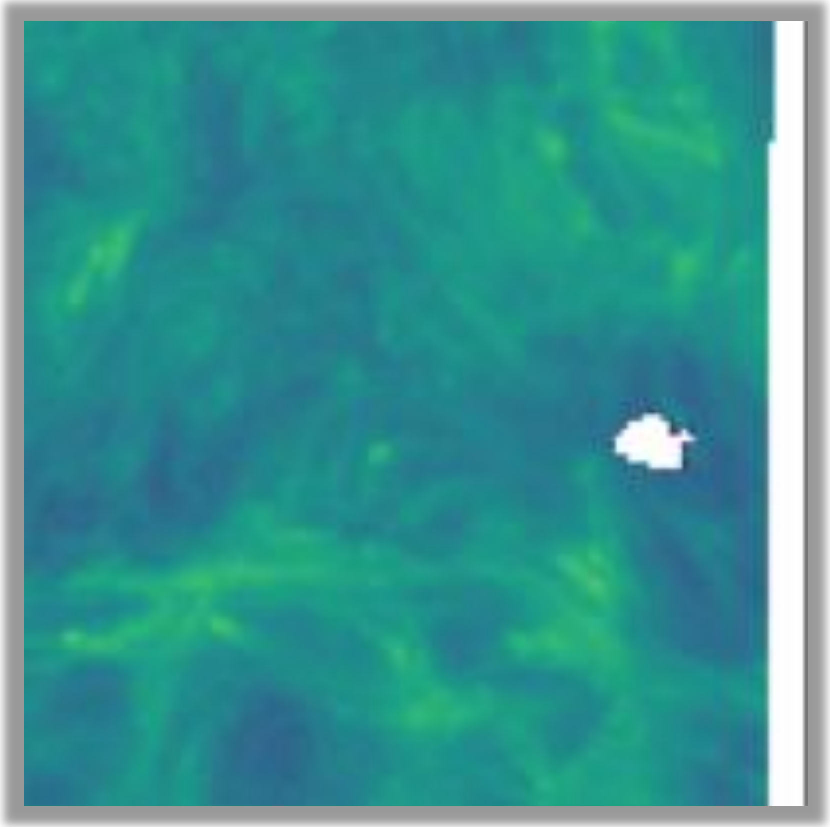


Our pipeline for automatic detection of flares

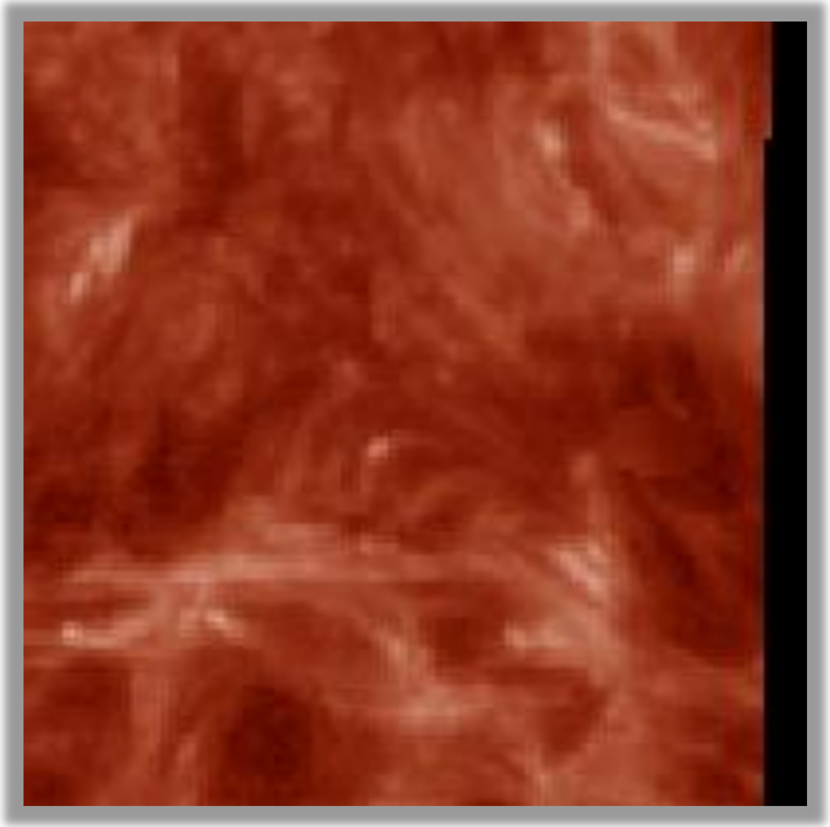
99% detection accuracy on 500 sequences of 10 consecutive frames for 1400Å SJI frames, with one sequence missed and no sequence with false detection

detection	true flare	true no-flare
flare	43	0
no-flare	1	456

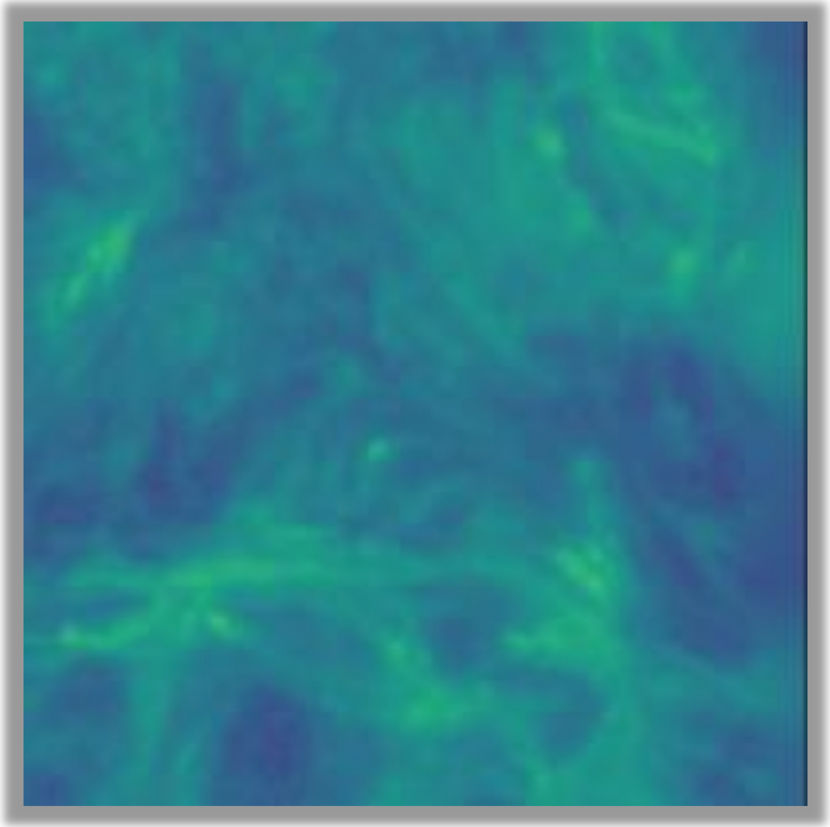
Preprocessing tool: quality dust remover



Original data



Classical inpainting tool



Our inpainting tool

Inspired by two articles:

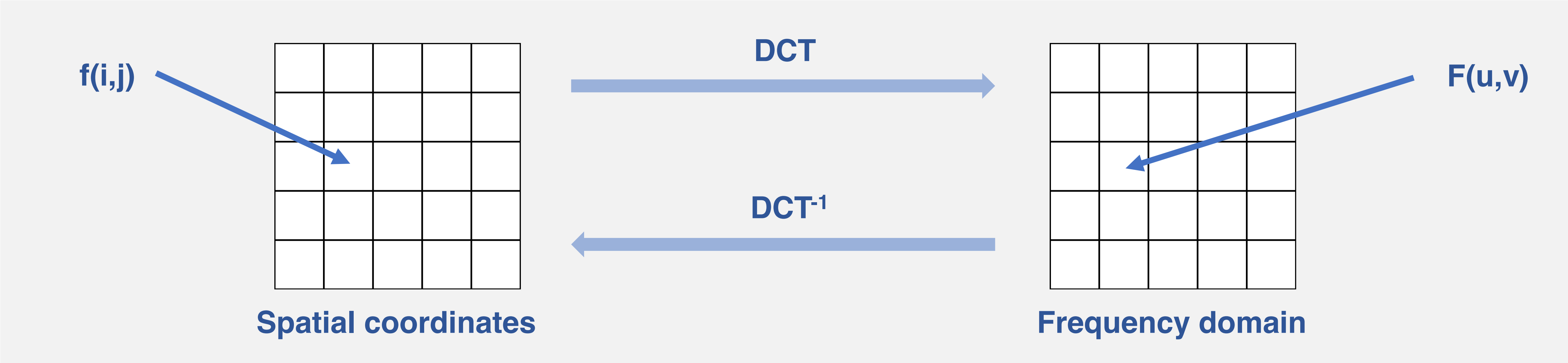
Garcia D. Robust smoothing of gridded data in one and higher dimensions with missing values. Comput Statist Data Anal, 2010;54:1167-1178
Wang G, Garcia D et al. A three- dimensional gap filling method for large geophysical datasets: Application to global satellite soil moisture observations. Environ Modell Softw, 2012;30:139-142

A bit of details: Frequency extraction

We are using ***discrete cosine transforms (DCT)*** *which are similar to discrete Fourier transforms (DFT): It transforms a signal (1D case) or an image (2D case)* ***from the spatial domain to the frequency domain*** *(Fig.2). It uses the* ***basis of cosines*** *instead of complex exponentials, which is* ***invertible,*** *computationally cheaper than DFT and well suited for real signals such as videos.*

Apply *2D DCT* for each frames

Prevents possible misalignment of spatial coordinates over time

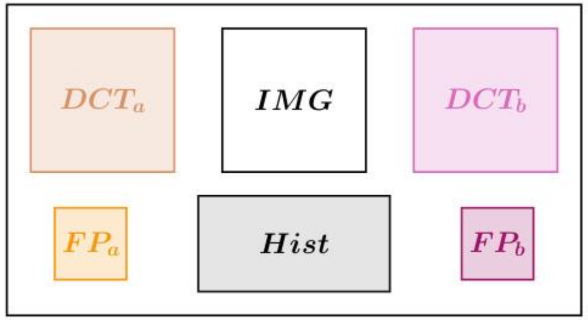


Apply *1D DCT* for each spatial frequencies coordinates

Extracts the frequencies of the temporal signal for each coordinates

Get the variances of those temporal frequencies

Video Result



Right part: future
Left part: past

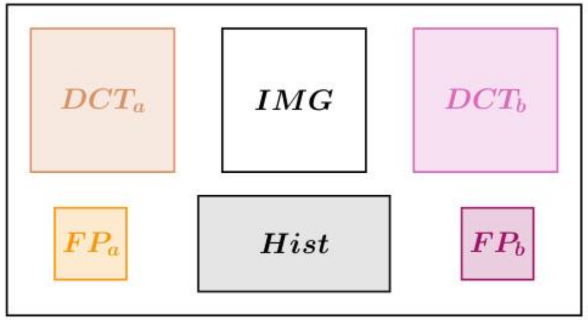
Analysis on the top

RESULTS AT THE BOTTOM

YELLOW: HIGH PROBABILITY

BLUE: LOW PROBABILITY

Video Result



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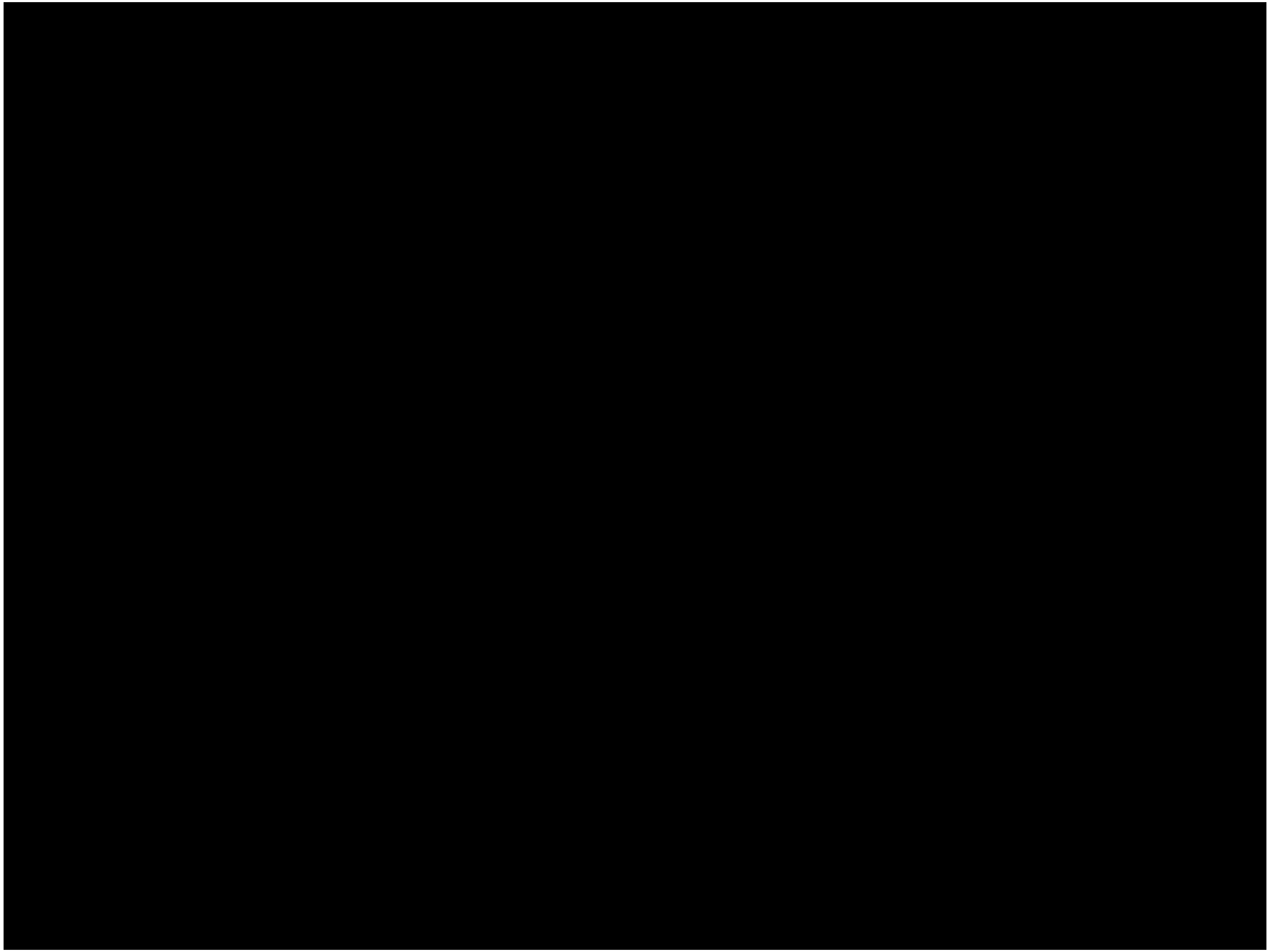

WANTED!!!

We are looking for labeled IRIS data

If you have flares identified on SJI
Or any other labels and details
If you would like to share your SJI analyzed data
For machine learning on IRIS data purposes

Please contact me

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Labeled data is requested for machine learning on IRIS