Capstrum: The fourier transform of a log-Magnitude Spectrum; the fourier transform of a func that gives the logarithm of Magnitude in terms of frequency

Eigenfunction Analysis of Coherent Structures on the Solar Surface

Spectrum: A graph of Energy against (Spectrum) freq.

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Mentor:

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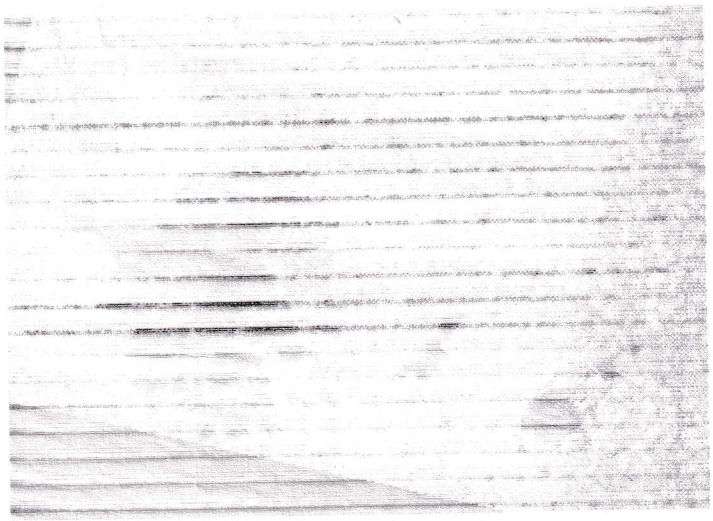
Research Objective



First frame of sunspot image data.

The appearance of structures on the surface of the sun, such as sunspots and granulation, has been studied for many years. In this project, we attempt to gain some understanding of the nature of the flow in such coherent structures by determining a set of empirical eigenfunctions which describe the flow such that the eigenfunction representation is most compact. This involves applying the Karhunen-Loeve (KL) transform to the observed data. These eigenfunctions determine the primary modes of the evolution of the structure.

Significance

The KL transform has been proven to be the optimal transform in terms of the information entropy in the eigenspace representation. This has several implications:

In image processing, it means that an image may be broken up such that the information content in the first N basis functions is higher, for any N, than in any other transform. This implies that for reconstruction of data compressed with a lossy transform and truncation operation, the KL transform can offer the best reconstruction of original data with the same number of retained eigenfunctions and transform coefficients than any other lossy compression algorithm, including the popular JPEG format.

For the study of coherent structures in turbulent flows, it means that the structure may be decomposed into modes such that the energy contained in the highest N modes is larger, for any N, than under any other linear transformation, including of course the Fourier Transform. This means that rather than using an arbitrary basis for studying coherent structures, the primary empirical modes may be decoupled and studied as they exist.

Computational Aspects

A C program was written and compiled to run on an SGI Power Indigo 2 (MIPS R8000) workstation