Local correlation tracking method using fast Fourier transform to determine proper motion of sunspots, using python.

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Abstract: Sunspots are darker regions observed on the solar surface. They are associated to the emergence of strong magnetic fields from the convection zone. After the magnetic fields emerge the sunspots evolve mainly due to three horizontal motion patterns: solar rotation, meridional flow and turbulent diffusion. In this work we apply a technique called Fourier Local Correlation Tracking (FLCT) to estimate the proper motions that are responsible for the evolution of a sunspot group associated to active region NOAA 12673. The FLCT technique consists in computing a local cross correlation in the wavenumber space between two images that are separated in time and obtaining the displacement vectors that are responsible for the evolution of the structures from one image to another. Dividing the displacement vectors by the time interval between the images gives us the velocity field responsible for the evolution of the structures present in the images. Active region NOAA 12673 appeared in the solar disk on August 28 2017, and crossed the disk center on September 3 2017. We apply the method to two images of the solar surface obtained on September 3 2017 in the continuum range by the instrument HMI (Helioseismic Magnetic Imager) onboard the SDO (Solar Dynamic Observatory) satellite. Before the method was applied, we removed the granulation contribution from the solar surface by applying a spatial filter. After removing the granulation, we selected a region of interest with dimensions 150x150 pixels around the active region. This region was further subdivided into 5x5 pixel boxes to calculate the local correlation, and two images temporally separated by an interval of 30 min were used for this calculation. The velocities field obtained is responsible for the temporal evolution of the NOAA 12673 sunspot group. We then analyze the resulting velocity field, looking for the presence of critical points and their classification, in order to account for the presence of converging vortex flows.

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