RoboSWOP

The Robotic Space Weather Operator

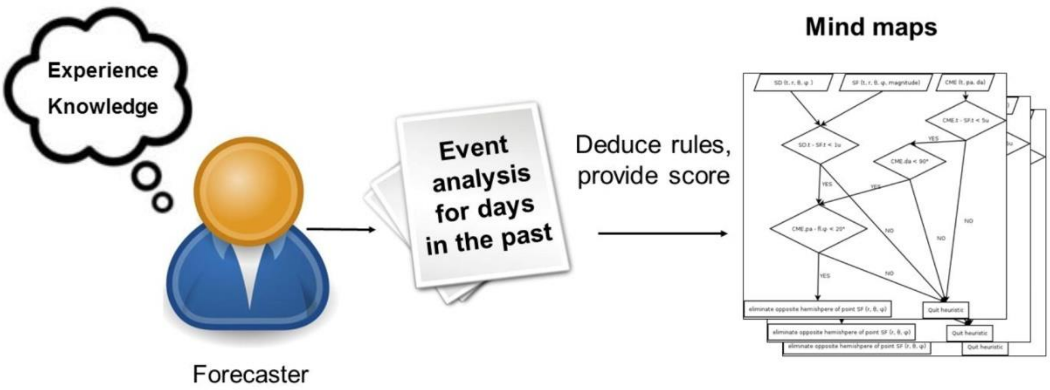
DURATION
15/01/2017 – 15/04/2019

BUDGET
149 800 €

PROJECT DESCRIPTION

The goal of this project is to demonstrate the feasibility of the 'Robotic Space Weather Operator' (RoboSWOP), an advanced software package that will generate fully automated coronal mass ejection (CME) reports that intelligently synthesise relevant information in a coherent fashion, ready for digestion into solar wind simulation codes. This goal will be achieved stepwise through the following three objectives:

- harvest the expertise of the space weather forecaster in a mind map,
- automatically associate solar events (e.g., flares, coronal dimmings, filament eruptions) in an event chain and
- automatically generate a geometrical reconstruction of a coronal mass ejection based on the information in the forecaster mind map and the event chain.



Coronal mass ejections are giant eruptions that expel plasma and magnetic field from the Sun into interplanetary space. They are the main drivers of space weather in the near Earth environment and can seriously disturb the magnetosphere, significantly damage electrical grids on Earth and disrupt communications. Therefore, an accurate prediction and early warning of CMEs is of uttermost importance to space weather science and operations.

A wide range of CME-related features is observed by remote sensing instruments operating at different wavelengths, such as filament eruptions and flares, large-scale coronal waves and dimmings in the Extreme Ultraviolet (EUV) and eruptions in white light coronagraphs. These different observations of solar events each provide a partial view on the CME phenomenon and its parameters, such as speed, acceleration, source region location, geometry, density and magnetic structure, which will eventually define the geo-effectiveness of the CME. The (human) space weather forecaster monitors the data and the observations of solar events and generates reports on a daily basis or in case of emergency.

In the process of space weather forecasting, the forecaster implicitly uses heuristics derived from experience. This project aims at capturing these heuristics through a number of 'mind mapping' sessions. The result is a set of rules that can be implemented in decision software code. As input for the mind mapping session specific periods in time that contain particular events are determined. During a mind mapping session, the forecaster is asked to perform CME forecasting for these periods, as if this was the present space weather situation. The forecaster explains the data he uses, his reasoning and his motivations to come to a conclusion about the origin, morphology and direction of CMEs.

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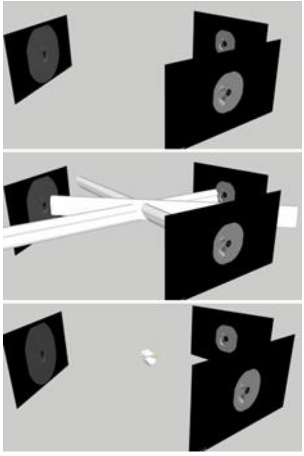
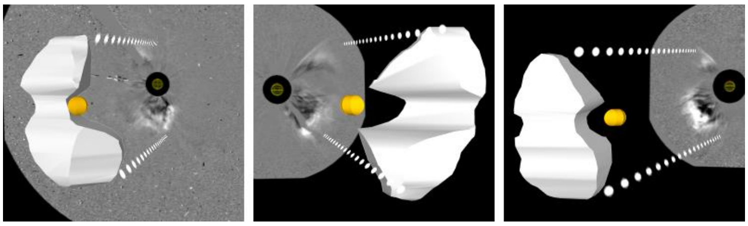
In the next step detected solar events that are related to each other will be automatically combined. The rules on how to relate different events will be deduced from literature studies, and existing automated and manually created linked event lists. Furthermore statistical analysis and advanced techniques such as artificial intelligence, support vector machines and/or neural networks will be used on event lists to generate additional rules on how to relate the solar events. The result will be a system that is able to link solar events (e.g., flares, EUV waves, plasma cloud) into one or more event chains and provide a confidence score to the chains.



The main purpose of the project is to combine the mind map, the original data and an event chain into one or more geometrical reconstructions of the evolution of the CME. From the event chain we deduce the start and end time, and select all corresponding coronagraph images for that period using as many viewpoints from coronagraphs as possible (e.g., instruments on board STEREO-A, STEREO-B, SOHO). Image segmentation techniques are applied to extract areas that (may or may not) contain a CME, and these masks are in turn used to carve out the CME in 3D-space. We will investigate if we can use events in the event chain (e.g., a filament eruption) to reduce the volume that represents a CME. This helps to reduce uncertainty in the carved out space for those events where the CME masks are ambiguous (e.g., low signal in the images) or when the alignment of the coronagraph viewpoints are sub-optimal. The mind-mapping rules will be used to further improve the remaining reconstruction. As a result of this space-carving process, we get a volume for each timestamp of an image in the timeframe of the event chain. The collection of these volumes represents the evolution of the CME in time. Existing CME models will be fitted on the carved-out CMEs to define the parameters of the event. The model fits will allow us to deduce the direction and change in direction, speed, acceleration and expansion rate of the CME. The model fits will be given a confidence score based on the accuracy of the fit, the scoring of the event chain, and the scores of the mind-mapping rules used during reconstruction.

When proved successful this project will improve the human space weather forecasters predictions of the orientation and structure of the CME and will increase the predictions of the impact of CMEs on Earth and the human life and activities.



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