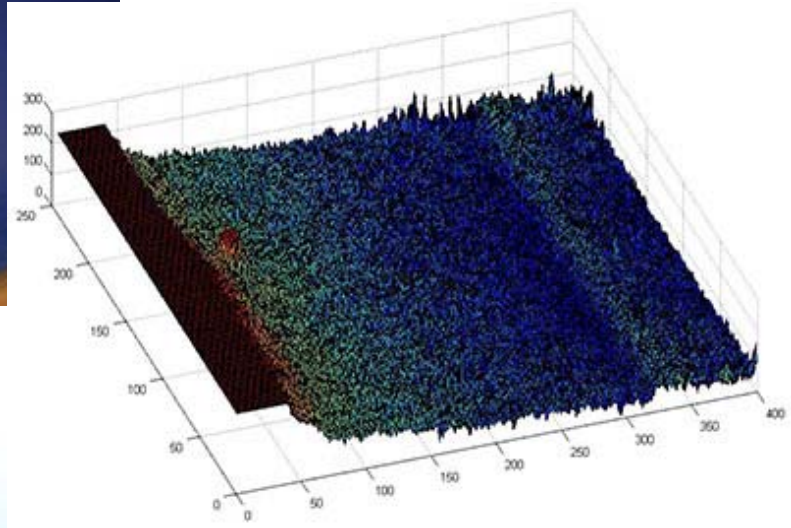
# Automatic Halo Recognition from Photographs

*Thoughts of feature extraction possibilities in halo images*

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# Outline

- Introduction
- Test photos
- Processing steps
- Data
- Features
- Discussion

# Introduction

- Aurora researchers have developed / are developing pattern recognition algorithms for their automatic cameras in order to
  - detect the presence of an aurora display
  - determine the duration of a display
  - classify the activity of a display
- An automatic halo camera system would benefit from such an algorithm as well
  - tasks would be similar: presence and duration of a halo display, recognition of halo forms etc.

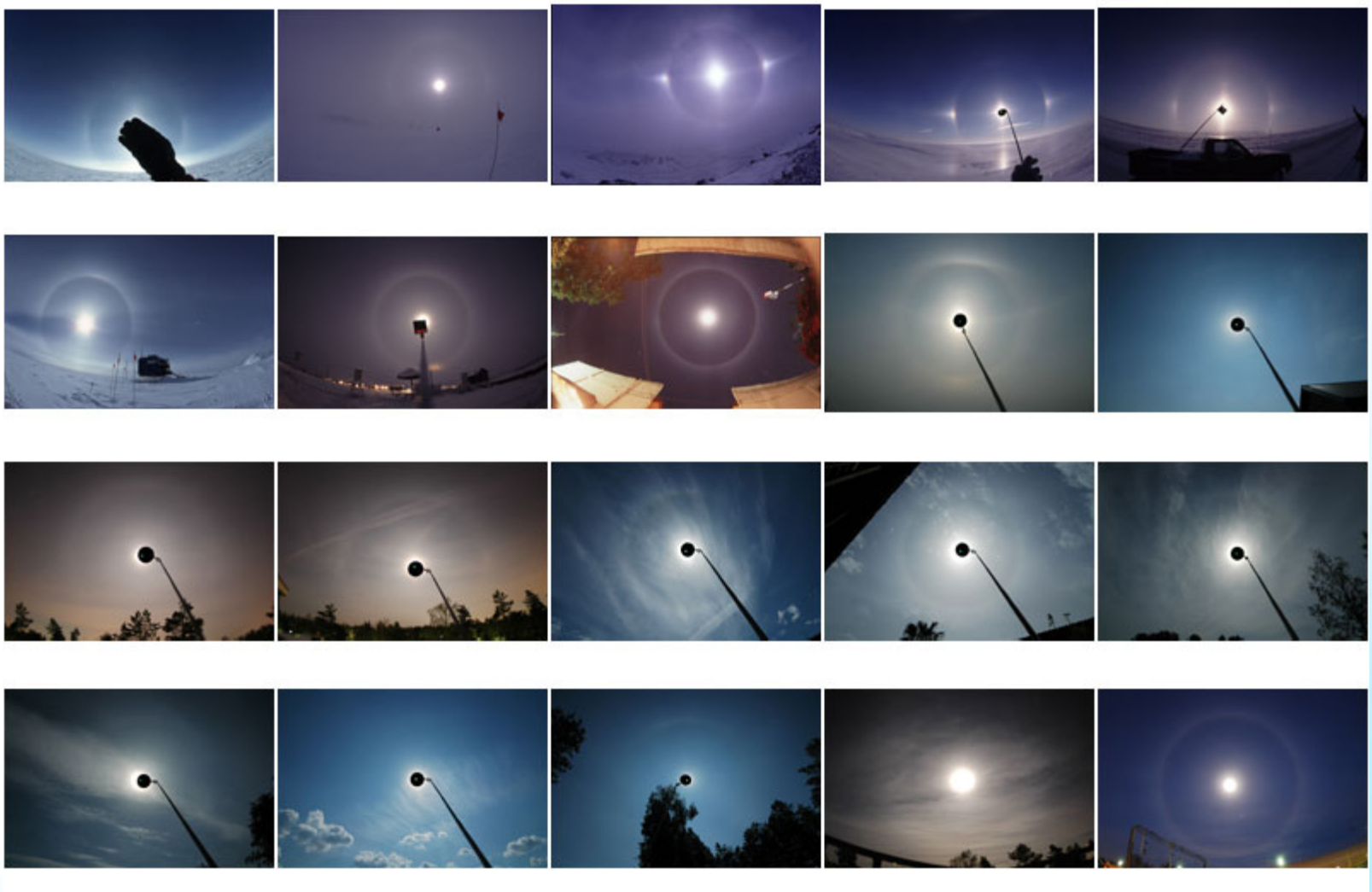
# Introduction

- Features that indicate the presence of a halo in the vicinity of 22° from Sun/Moon have been studied in Matlab environment
- The image processing steps that are needed for feature extraction are outlined and a preliminary set of promising features are presented

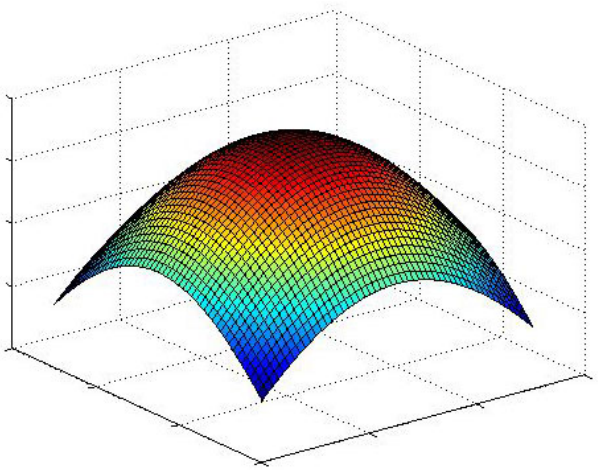
# Test photos

- A set of test photos was selected
  - 8 bit amplitude resolution digital RGB images (jpeg-format)
  - Some were scanned and some were captured with digital SLR camera
  - Lenses were 16mm (full frame and Nikon DX) and 12mm (Nikon DX)
  - The set includes day- and nighttime halos, weak and strong halos and homogeneous as well as cloudy backgrounds
  - Image size 1280 x 851 px

# Test photos



# Processing steps



- In order to enhance contrast, especially in case of weak halos, an unsharp mask filter is applied
  - first step is to blur a copy of the image with a gaussian low pass filter using a convolution kernel 51 x 51 pixels in size with the Gaussian std being 40 px.

# Processing steps

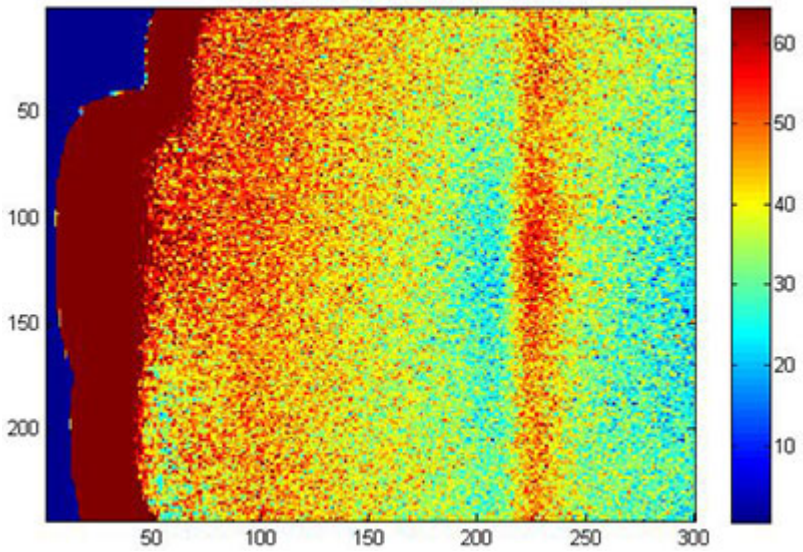
- Next and final step is to subtract the blurred copy ($I_B$) from the original ($I$):

  $I_{USM} = a * I + (1-a) * I_B$, $a > 1$
- When blurring is performed using the values presented in the previous slide and the value of $a$ is selected to be 10, the filtering has the same effect as Photoshop usm (500,40,0)

# Processing steps

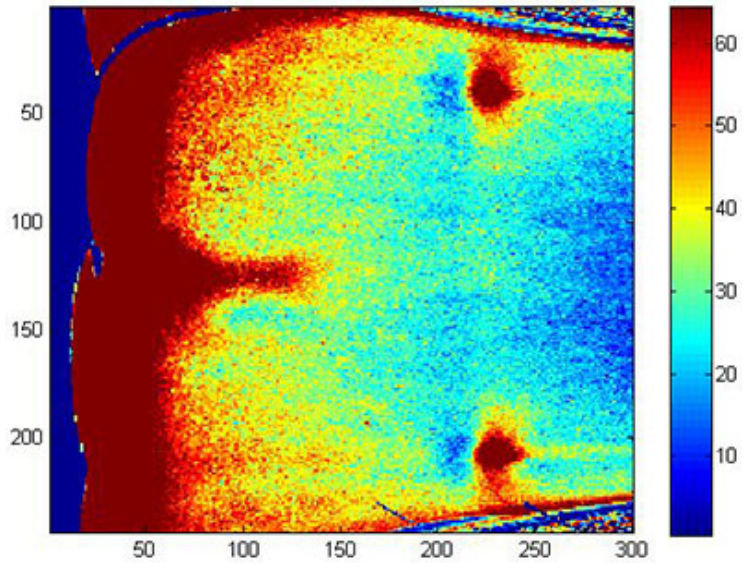
- Only a small amount of all image data is selected for use
- Lines, that define the pixels from where the data is collected, are drawn from the Sun to a distance of ~30° from it.
  - Sample lines are radial and are separated by 1°
  - 250° sector is considered
  - Data from each colour channel is collected separately

# Data




- Now we have data ready for inspection
- Here is an example of red channel data
- Data has a lot of noise in it, so averaging is needed to obtain meaningful features

# Data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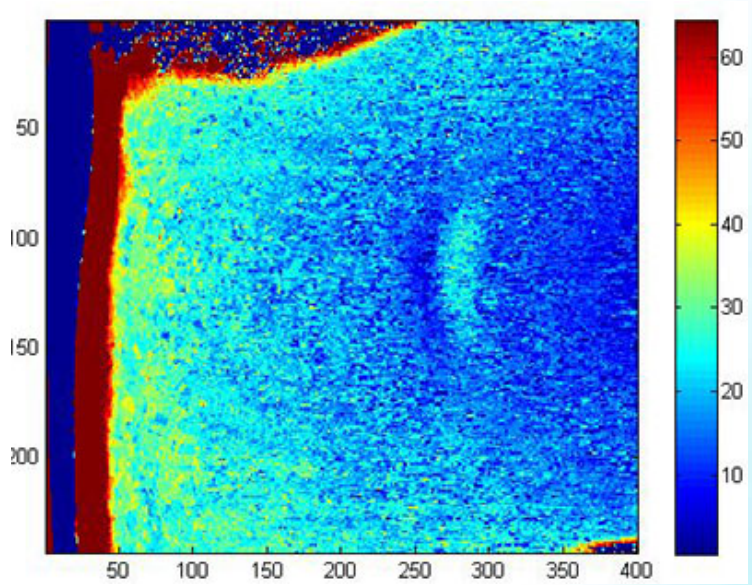
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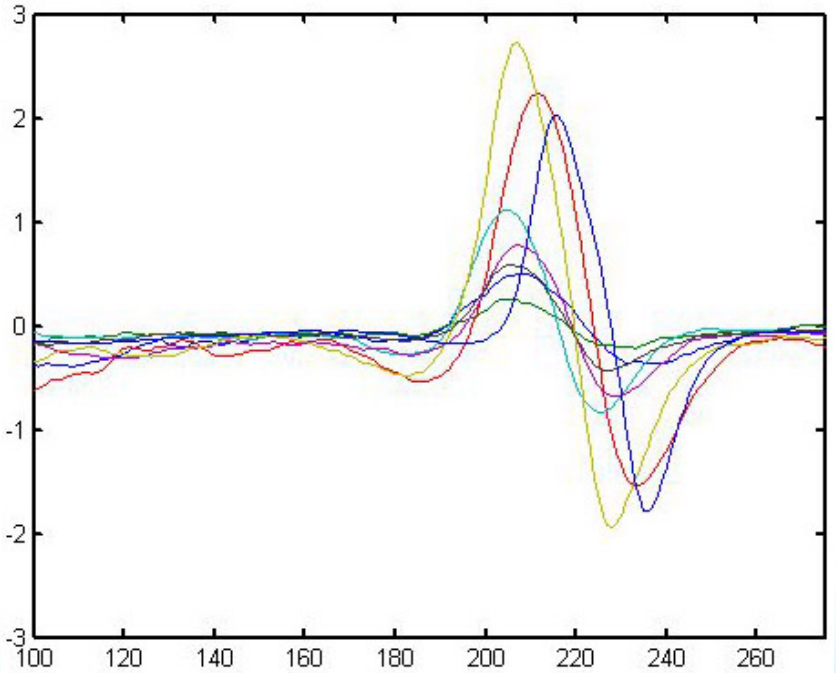
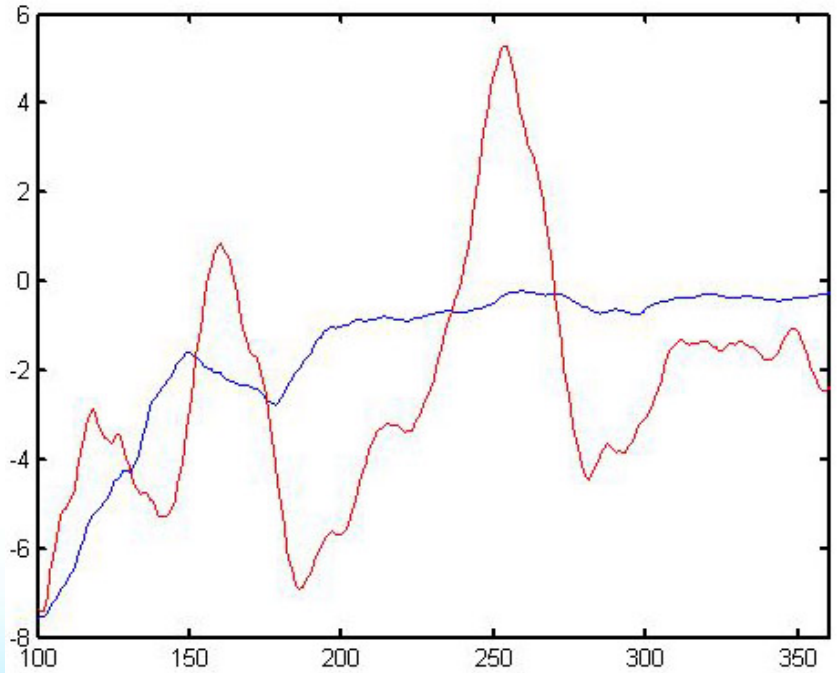
# Features

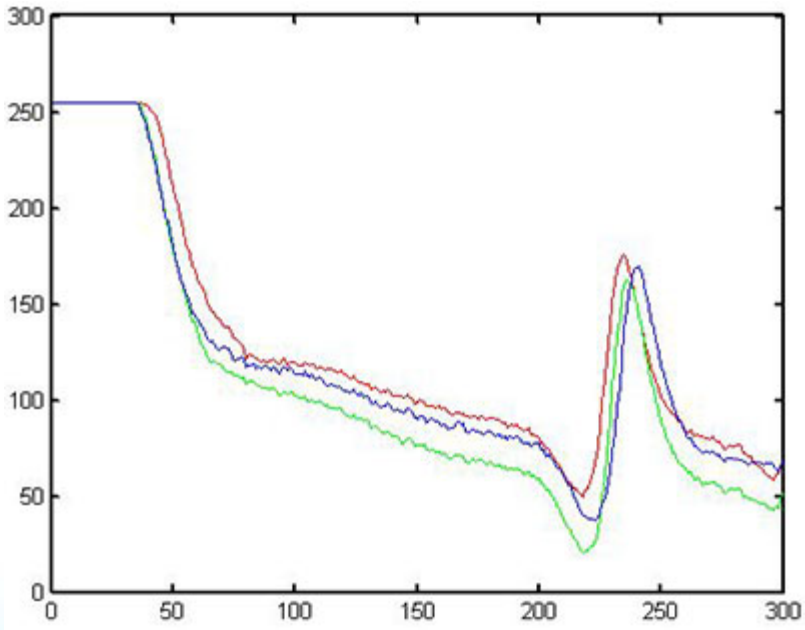
- Derivative of an averaged dataset
  - In 19 cases out of 21 the value of the derivative is > 0 at halo location – seems to be a good feature

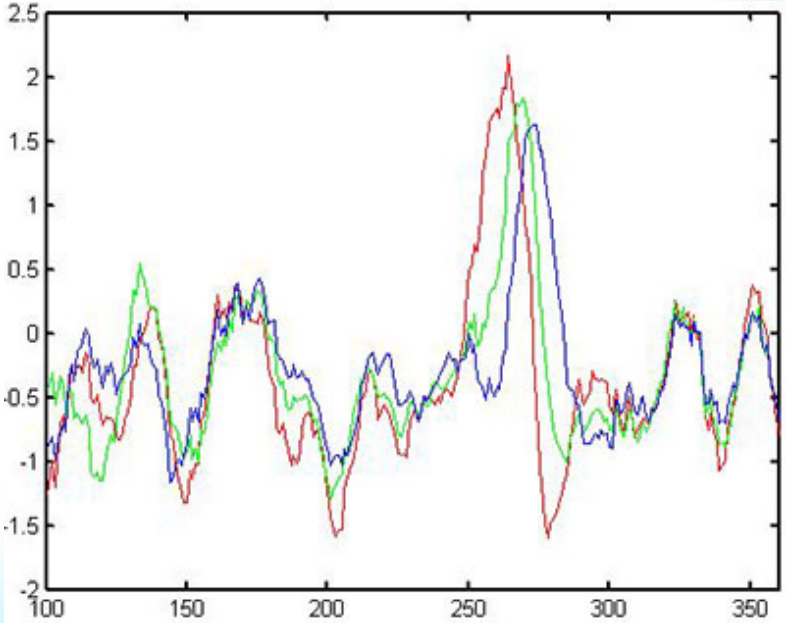


# Features

- Derivative can exceed 0 because of clouds or other elements
  - Solution is to study the three colour channels



# Discussion

- The derivative method fails in two of the test photos and the three colour channels do not bring the halos above threshold either
- The two cases are:

# Discussion

- In case the halo is very local and faint (solitary 23° upper plate arc for example) the presented techniques fail
  - if the angular data is divided into sectors which are considered separately, the possibility to detect ”short” halos or faint halo patches is increased
  - if stacking method is utilized, the signal-to-noise ratio is improved, which in its part makes detecting faint halos easier

# Discussion

- The presented features provide good results for well defined halo displays
  - in case a true pattern recognition algorithm would be used the number of independent features should be larger
  - classification of different haloforms is possible
    - reliability is increased by integration over time (stacking)
    - the mapping function of the optical device should be known