

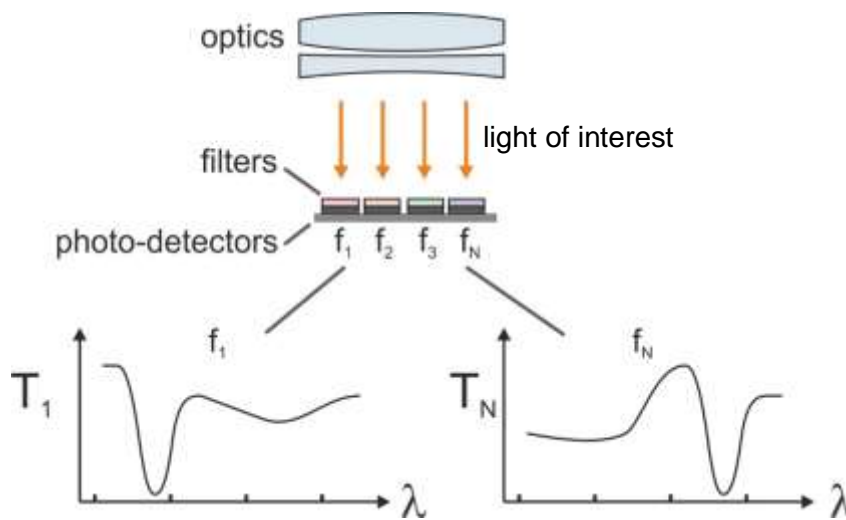
## Data Processing for a Filter based Miniature Photo-Spectrometer – Master Thesis

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In the last years the needs for miniature photo-spectrometers ( $< 250\text{cm}^3$ ) has significantly increased. The main drivers are: reduced time for results, analyzing in situ, decreasing cost and increasing ease-of-use of systems for use by non experts. A prominent manufacturer of such spectrometers is Hamamatsu. Such a spectrometer e.g. for the visible has a size of  $20.1 \times 12.5 \times 10.1\text{mm}^3$  and resolution 15nm. A promising application of such miniature spectrometer was recently reported as non-destructive testing of fruit ripeness (Scientific Report 6 32504 2016 Das "Ultra-portable, wireless smartphone spectrometer for rapid, non-destructive testing of fruit ripeness").

CSEM carried out a first phase optics development of a miniature photo-spectrometer. The data processing is not yet established.

The core components of the photo-spectrometer are N transmissive filters of a few micrometer size mounted on top of a N photo-sensor array. An sketchy illustration of the optical set-up is shown in Figure 1.



**Figure 1** miniature photo-spectrometer based on optical filters  $f_1 - f_N$ , with its filter transmissions  $T_i$  depending on wavelength  $\lambda$

### Characterization of the filter / detector system

First the filter / detector system is characterized by acquiring the photo-sensor signals when the system is exposed to scanning narrow-band light from a monochromator illuminated with a broadband light source. For a wavelength range from  $\lambda_{lo}$  to  $\lambda_{hi}$  and a fixed narrow-bandwidth of  $\Delta\lambda$   $M = (\lambda_{hi} - \lambda_{lo})/\Delta\lambda$  measurements are carried out. Thus a "filter matrix"  $F$  with  $M \times N$  measurement points are generated.

### Measurement of a unknown light source

For a modest number of filters/photodetectors  $N < M$  an unknown light source is illuminating the spectrometer and N photodetector signals are acquired  $Y_i, i = 1..N$ . The true spectrum of the light source is  $X(\lambda)$ .

### Objective

The objective is now to estimate the spectrum of the unknown light source as good as possible by processing the "filter matrix" and the measurement  $Y_i, i = 1..N$ .