Calibration of a Multi-Object Spectrometer with Programmable and Arbitrary Field of View

Presented by **Marion O'Farrell**

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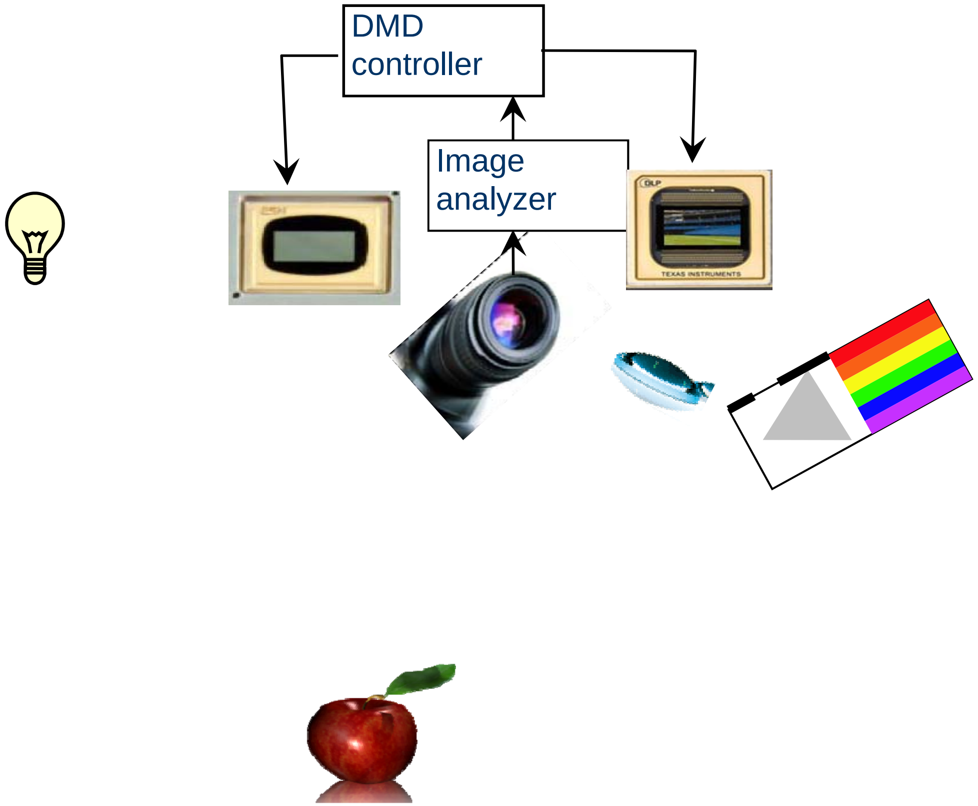
Outline

- Motivation (issues when taking spectral measurements from the lab out into producing industry)
- Background (show how reflections form other non-relevant object and multiple reflections form the surroundings interfere with the spectral measurements)
- DMD setup (tell how out setup solve this by controlling both the illumination and the measurement areas)
- Calibration/referencing needs (which needs for calibration is needed to do robust spectral measurements in general(?) and which challenges does this introduce to our dynamic system)
- Idea (present the idea of using a reference bank)
- Implementation (how we are thinking of and are solving this)
- Tests (how we have tested this idea)
- Results (present results for these tests)
- Summary and conclusions (what have been presented and which conclusions can we draw from this)

Industrial spectral measurements require flexibility

- In an industrial setting:
  - samples are seldom well-ordered
  - objects vary in size, shape and reflectance properties
  - background levels fluctuate
- Thorough analysis of the measurement situation:
  - spatial resolution
  - spectral resolution
  - wavelength band of interest
- Imaging spectrometer solutions:
  - scanning point measurement,
  - using dispersive element, a camera, and a scanning action, either by using a mirror device, for example a Digital Micro-mirror Device (DMD), or by moving the sample itself

A DMD (Digital Micro-Mirror Device) Based Multi-Object Quasi-Imaging Spectrometer



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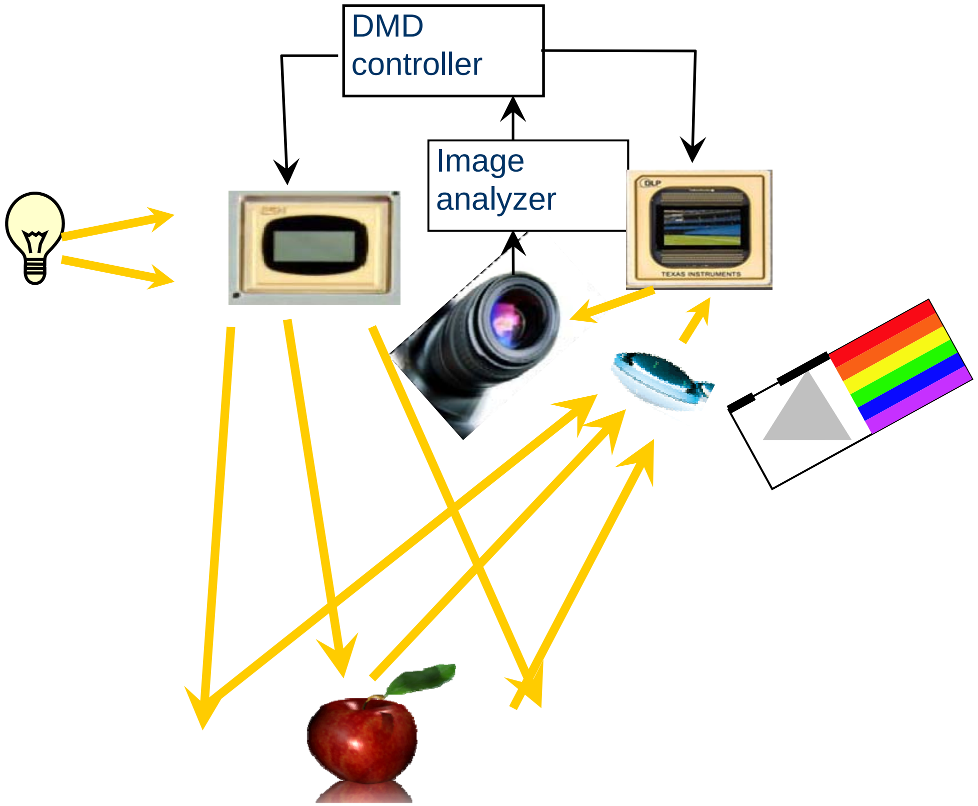

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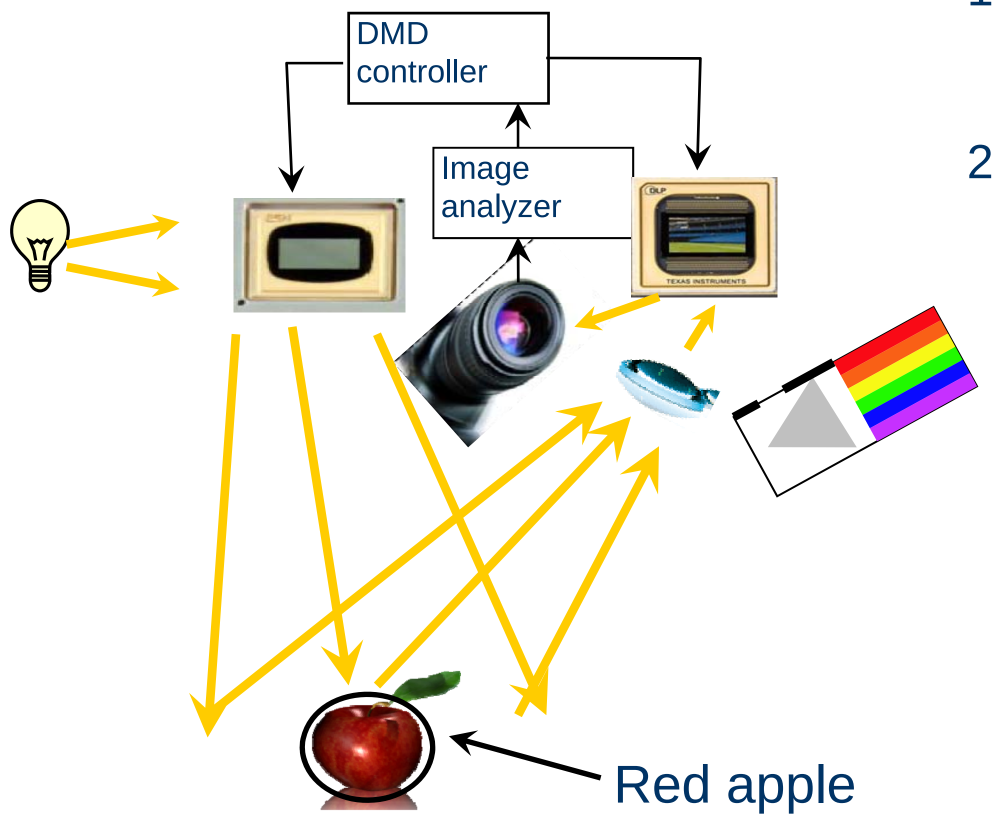

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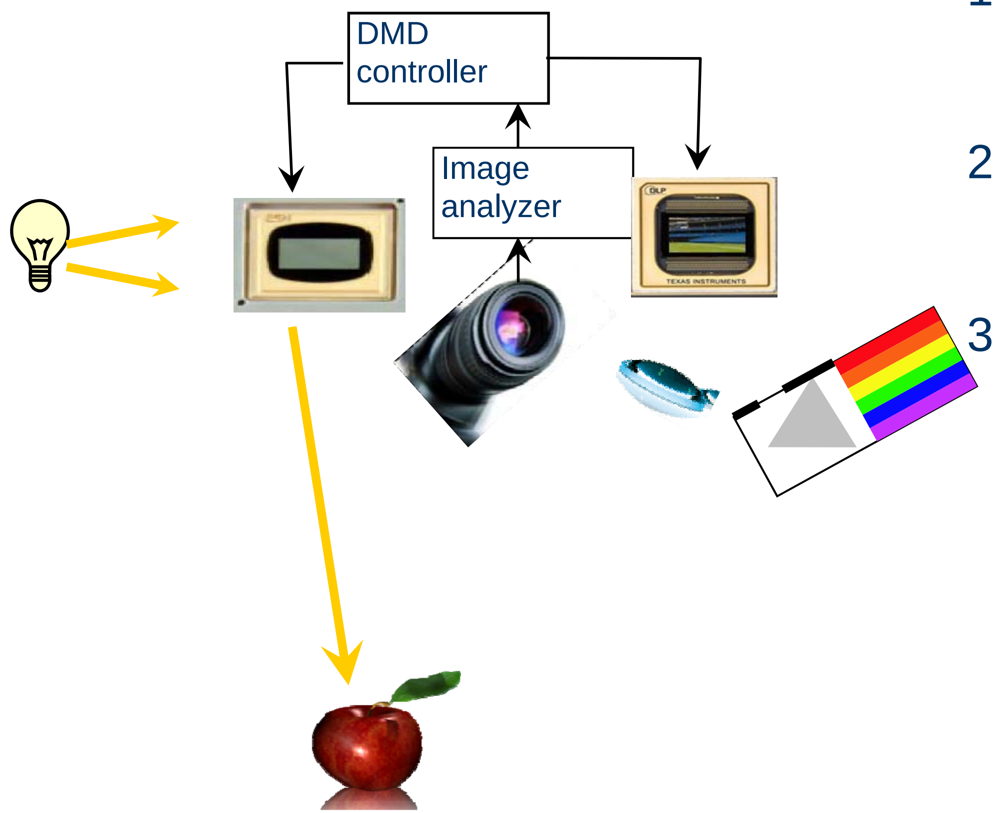

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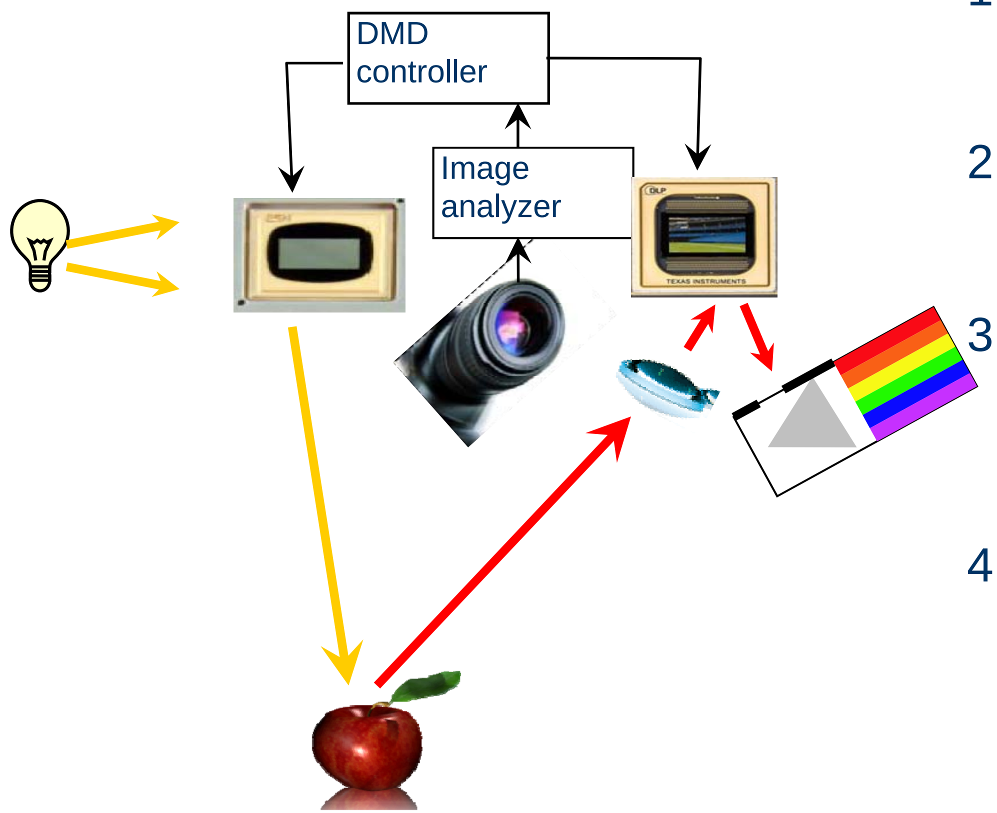

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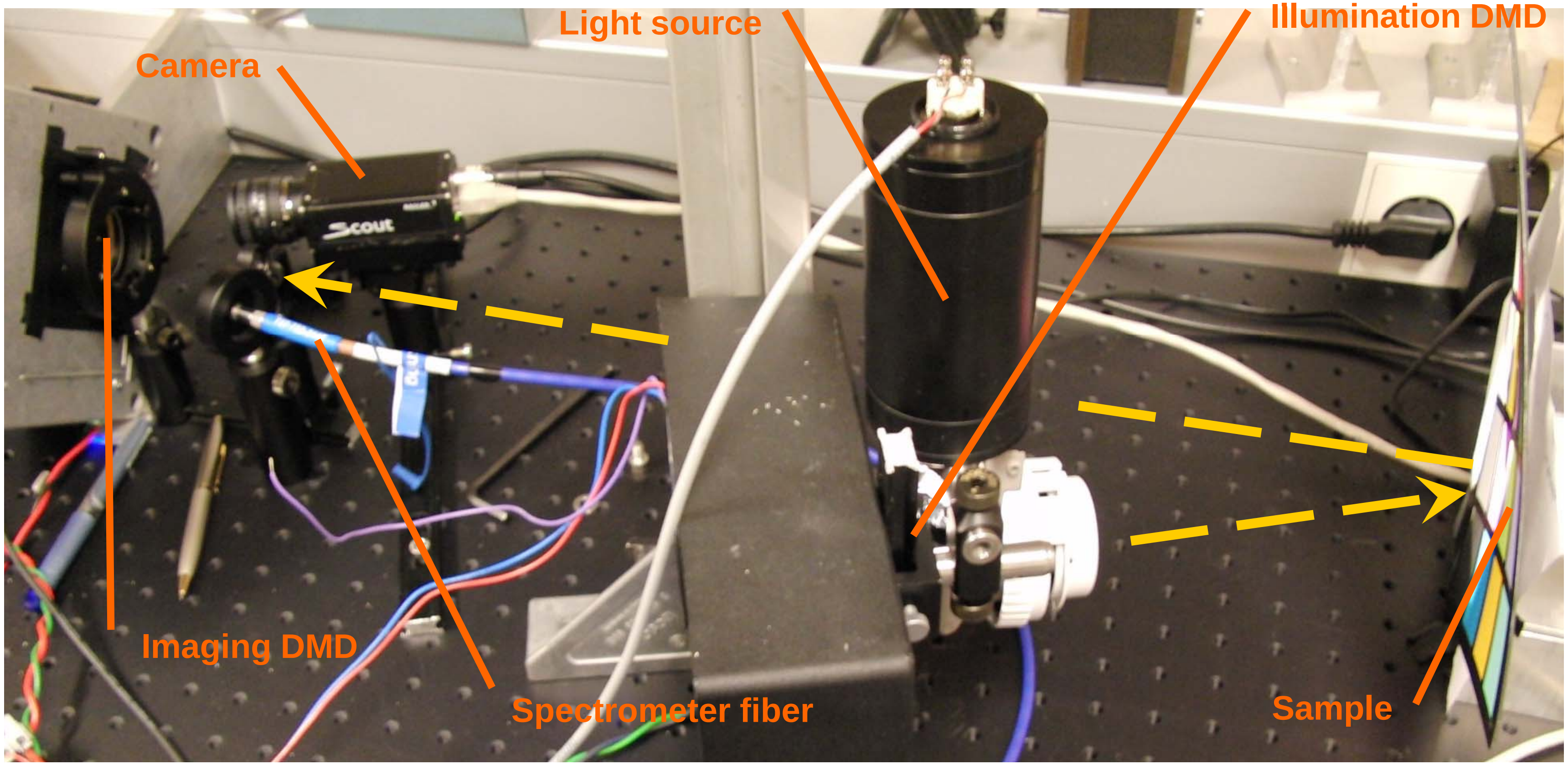
Digital Micro-mirror Devices are used to make a fully programmable quasi-imaging spectrometer



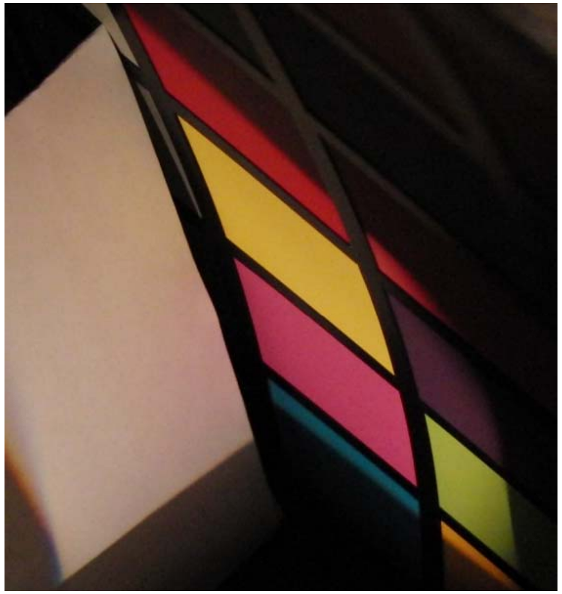
Lab setup: DMD with electronics form Visitech (LuxBeam SXGA+ DLP board) Optics from a standard low-cost office projector

Programmable field of view introduces challenges

- The spectrometer's response is usually dependent of:
  - angle-of-incidence of the light entering
  - illumination intensity varies over the scene
  - illumination intensity varies with distance from the light source
  - the illumination's spectral distribution may vary over the scene

  - the spectrometer's response is dependent on temperature

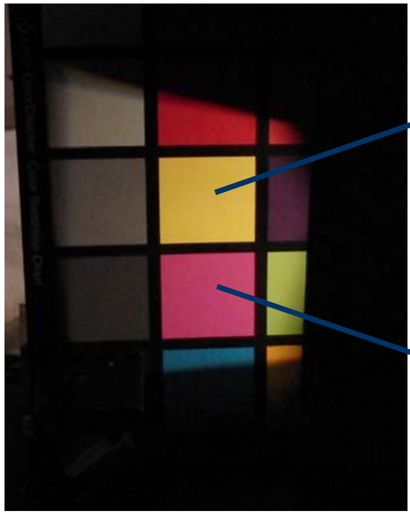
The sample contaminate the illumination source

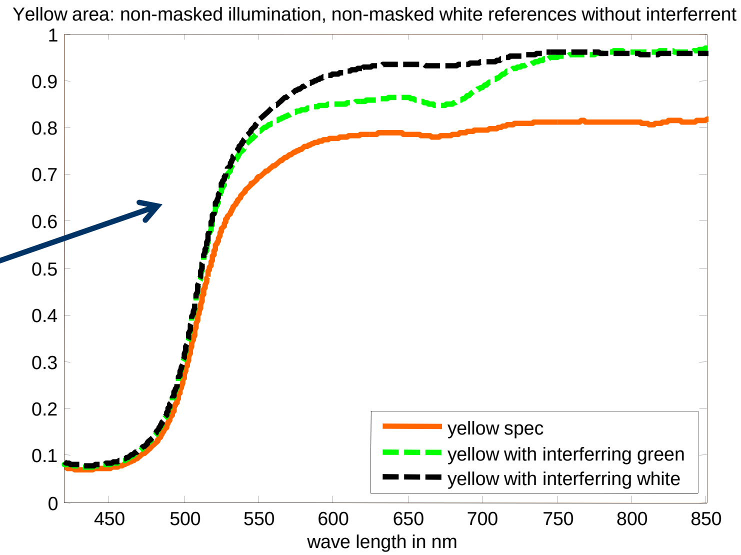


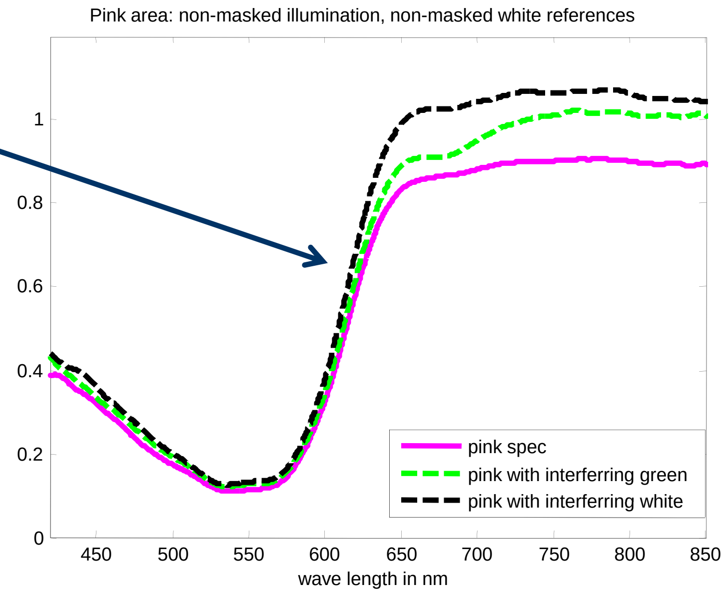
- Adjacent objects influence the spectral measurements

- The surroundings and the object itself influence the spectral measurements

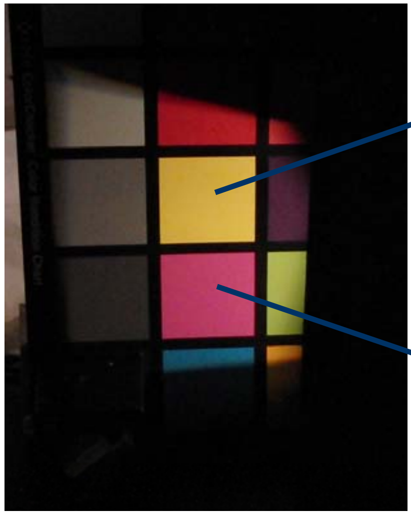
Nearby objects introduce spectral shifts

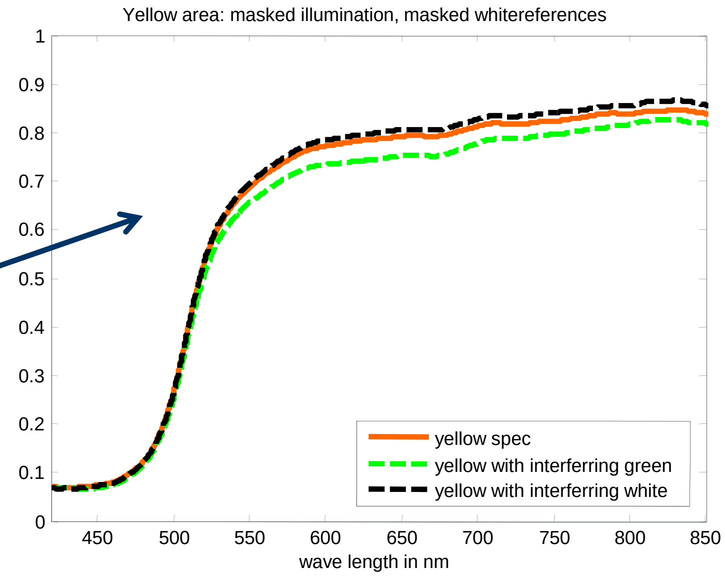


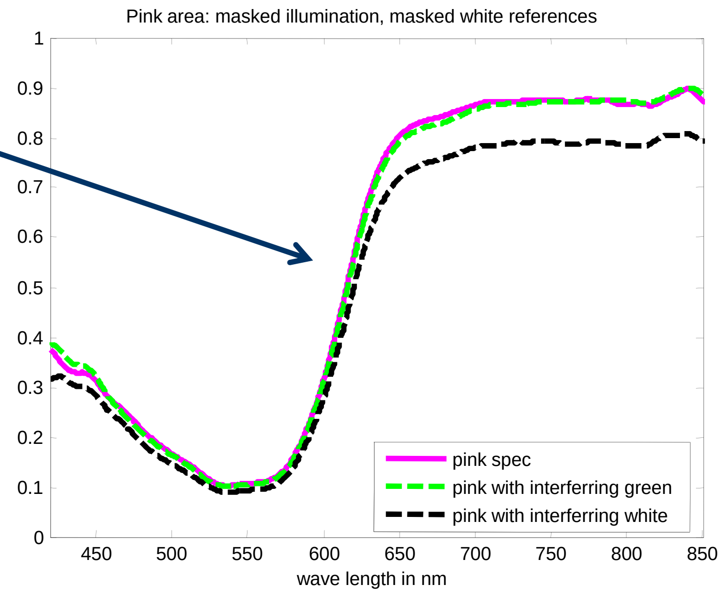




Stray light is avoided using designed illumination







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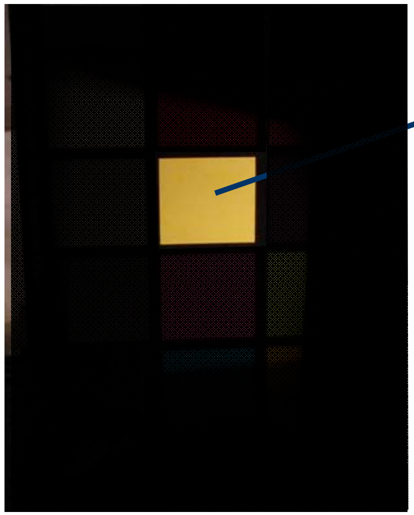

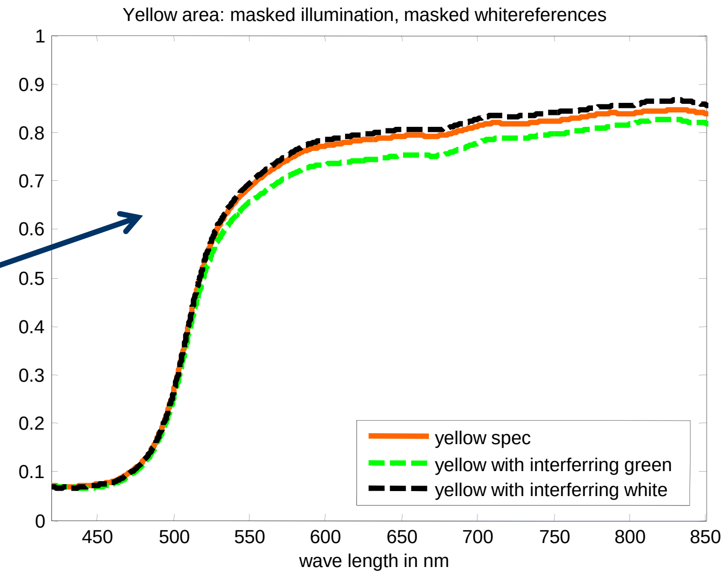

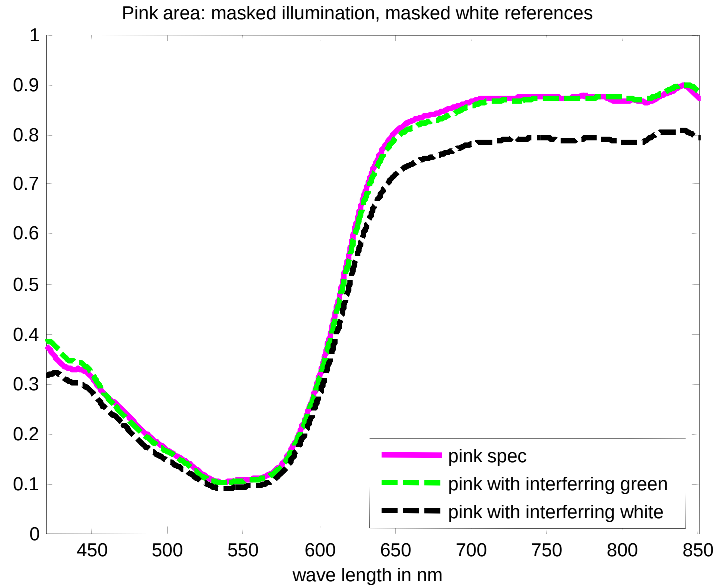

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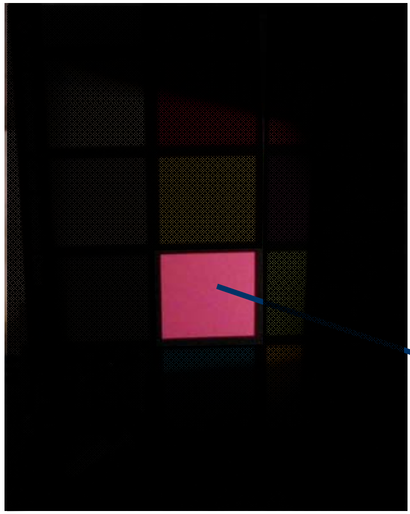
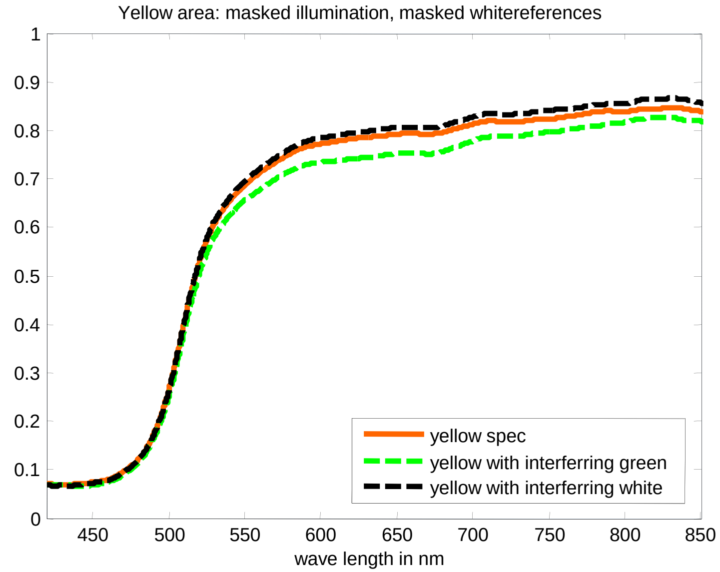
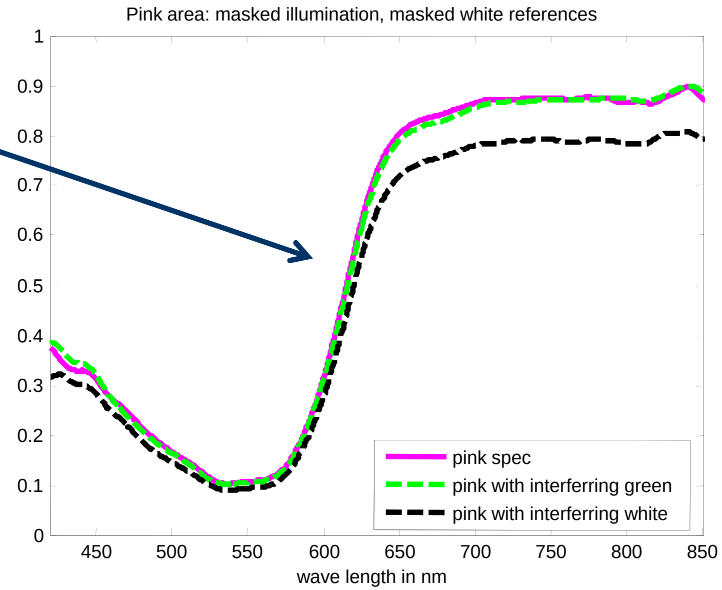
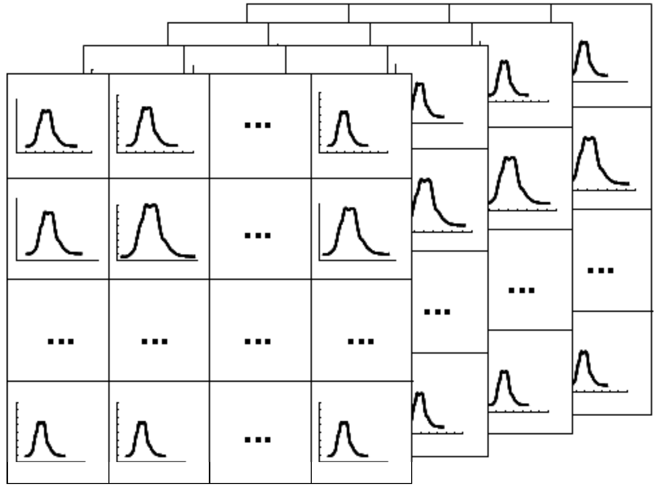






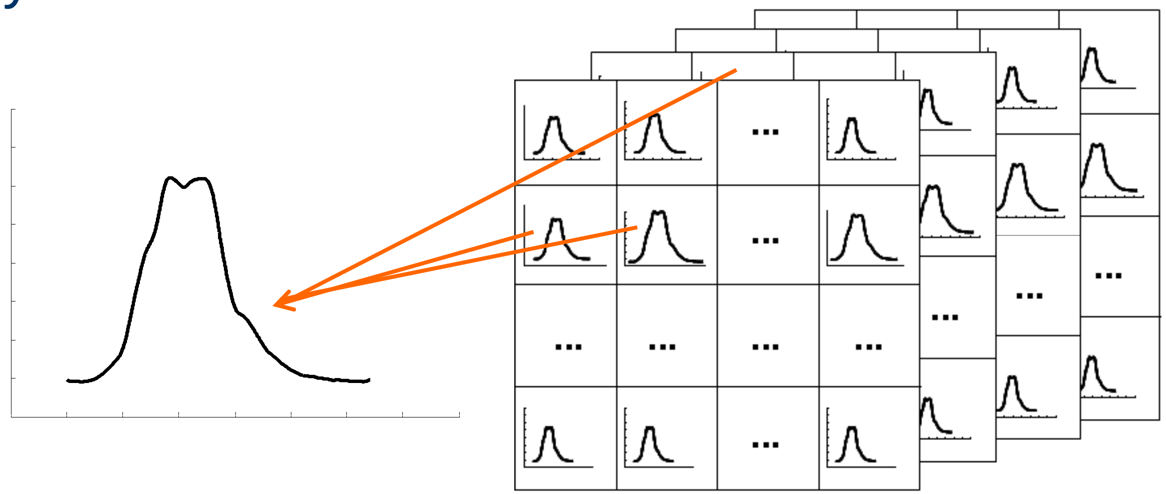
Build a database to dynamically generate reference spectra



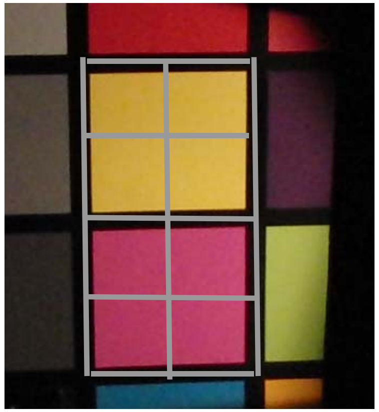
- Dividing the scene into cells and generating a reference spectrum for each cell
- The cells must fill an xyz-volume covering the intersection between the field of view and the field of illumination in the system
- The reference spectrum in each cell will be either measured or computed based on some references measured and knowledge about the physical properties of light and the system

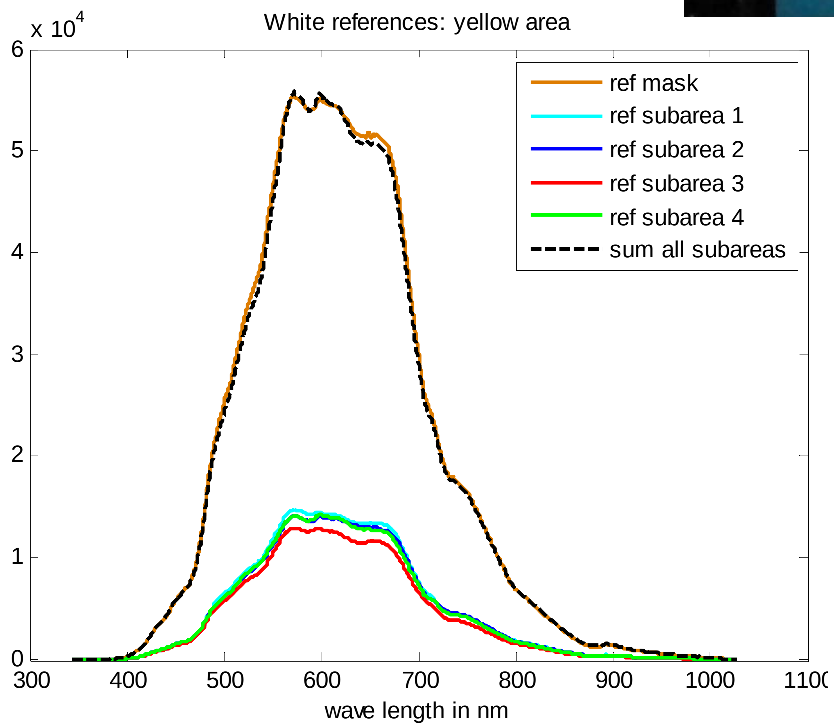
Fit reference spectra to the current region of interest

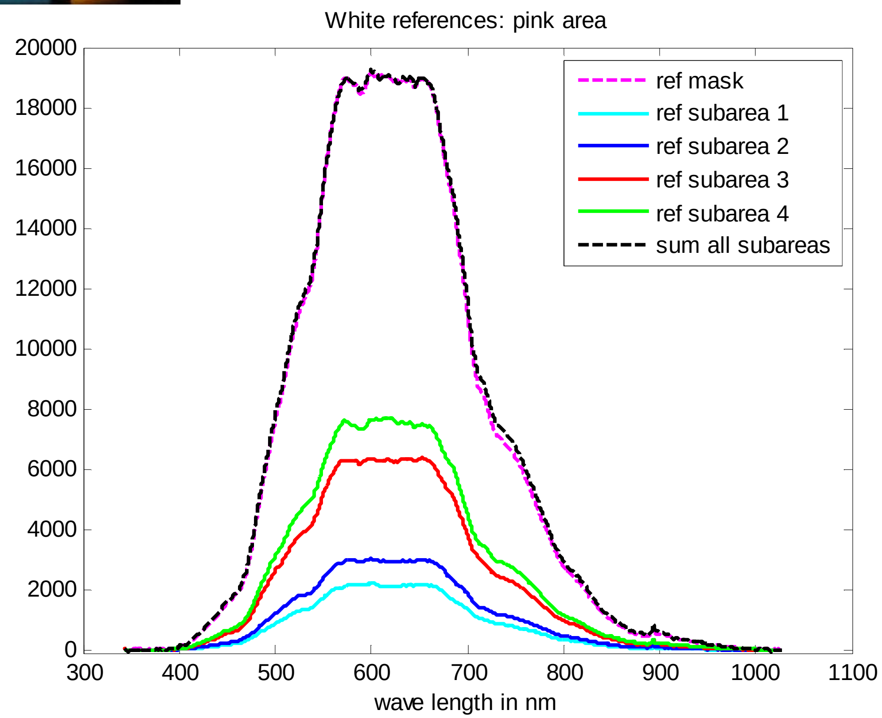
- Spectra in the cells corresponding to the object of interest are picked from the reference bank.
- These spectra are averaged to get the correct reference spectrum.
- This spectrum will thereby correspond to the size, position, and shape of the object of interest.
- The size of the cells must be large enough to get satisfactory signal-to-noise ratio, and small enough to provide adequate flexibility



Adding reference from sub-areas is similar to using a one to one reference







Spectral referencing databank meets the requirements of referencing in a dynamic system

- Shown the benefits of dynamic spectral measurements and how it reduces the effects of stray light in an realistic setting
- Introduced our DMD spectrometer set up
- Presented and demonstrated how a white referencing database can be made
- Measurements show that this approach meet the requirements of dynamic referencing

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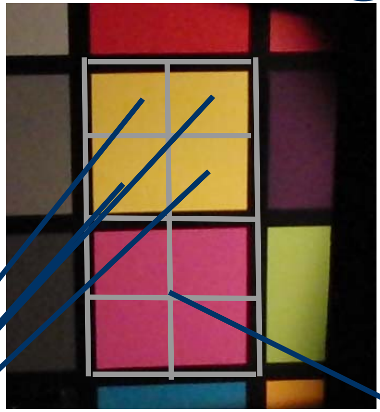
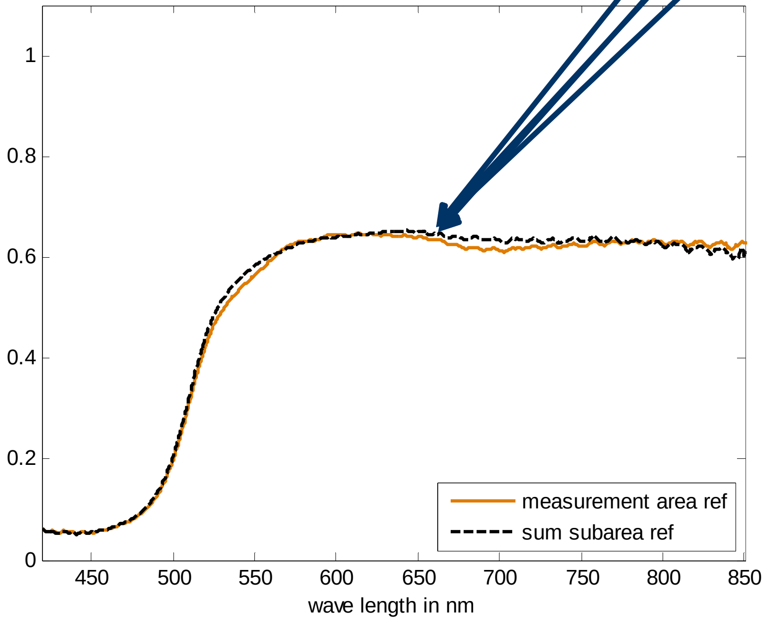
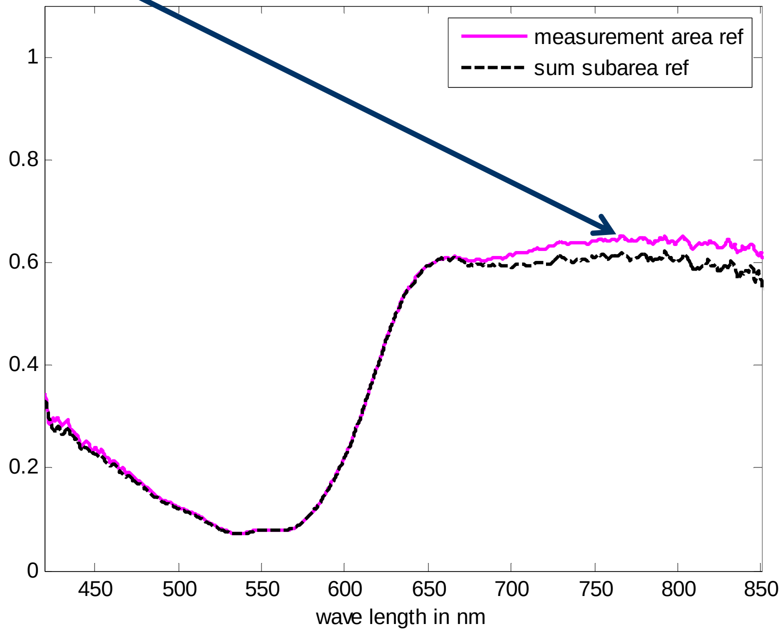
Using a mean reference from sub-areas is similar to using a one to one reference



Yellow area: masked illumination, sub area white references



Pink area: masked illumination, sub area white references



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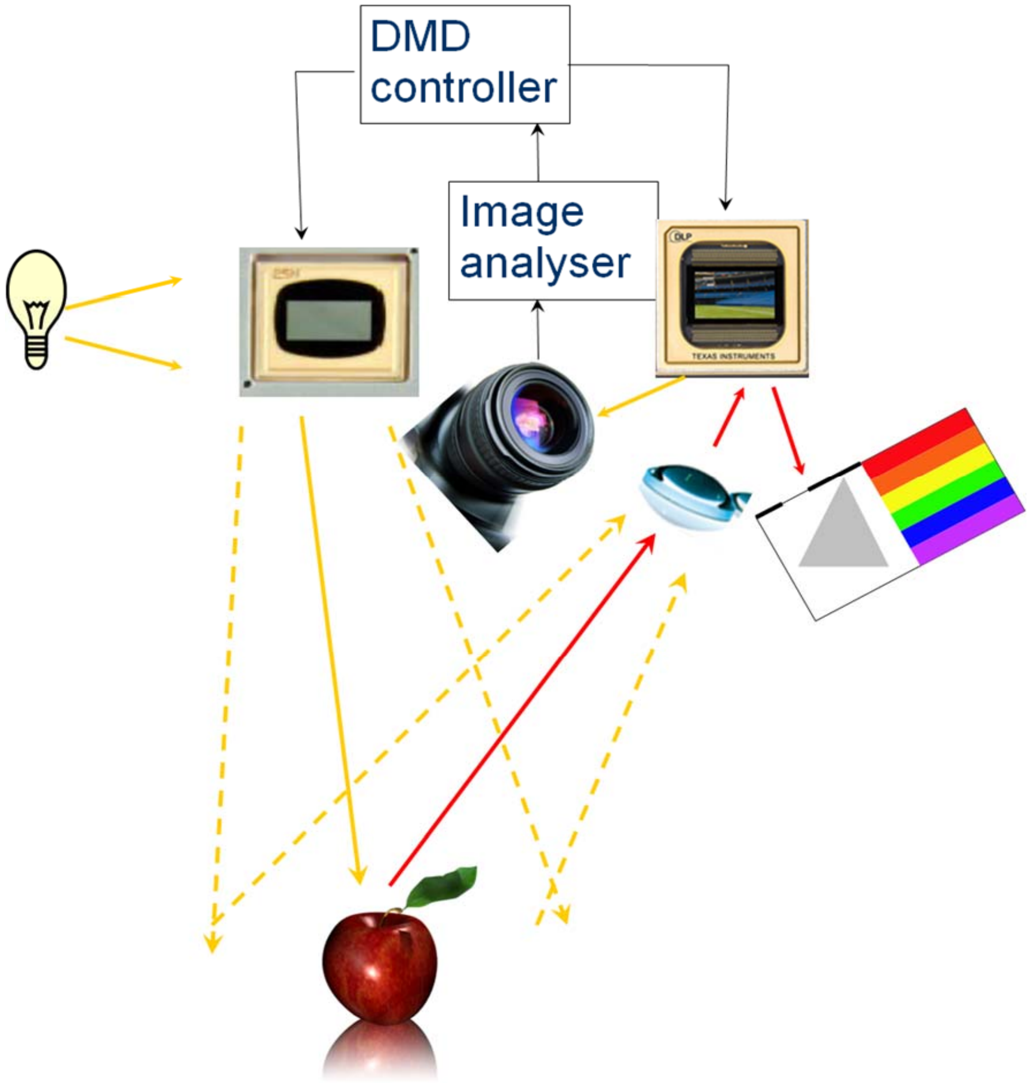

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