Prism-based multispectral imaging for machine vision applications

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Towards imaging beyond conventional color..

Object-based recognition
Feature-based recognition
Color-based recognition
Spectrum-based recognition

Spectral Imaging:
Core of future in machine vision
Multispectral Imaging

Theoretical example (VIS Spectrum):
Resolution Filters (= channels)
44 nm 9 filters
66 nm 6 filters
130 nm 3 filters

Can be 2-10 channels
Machine Vision Imaging Technologies

Overview

Cameras with On-Pixel Filtering

Multi-line Cameras

Multi-Sensor Prism Cameras

Bayer-Pattern Sensor

Imec Mosaic hyperspectral sensor

Optics
On-Pixel-Filtering Cameras

Bayer-Pattern

- Compact on-sensor color filtering
- High volume -> low price
- Sensors with high pixel count available offering large field-of-view (FOV)

- Most of the light hitting the sensor is blocked and thus lost
- Color information needs to be interpolated from neighbouring pixels
- Cross talk between neighbouring pixel resulting in color channel cross talk
Multi-Line Cameras

- Full color information in every pixel
- Compact on-sensor color filtering
- Flexible: 2 - n lines possible

- Line scan, only
- Halo artefacts when
  - camera is not oriented perpendicular to web
  - objects are moving unpredictable (e.g. free-fall objects)
  - 3D objects imaged
Multi-Sensor Prism Cameras

- Full color information in every pixel!
- Better color contrast and differentiation
- Line and Area scan cameras available
- No halo effects
- Light is separated not blocked off -> high sensitivity
- No crosstalk between color channels
- Full color resolution
- Customizable color separation

- Higher price
- Optimized lens required
- Larger housing
- Limited pixel count resulting in smaller FOV
Hyperspectral Imaging

Theoretical example (VIS spectrum):

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 nm</td>
<td>400 #</td>
</tr>
<tr>
<td>2 nm</td>
<td>200 #</td>
</tr>
<tr>
<td>5 nm</td>
<td>80 #</td>
</tr>
<tr>
<td>10 nm</td>
<td>40 #</td>
</tr>
</tbody>
</table>
Hyperspectral Imaging

Applications within geo-terrestrial imaging: earth surface, climate change: drying of rivers, loss of forests etc.

Hyperspectral Imaging

Applications within vegetation analysis: NDVI, soil quality etc.

https://www.aerialanalysis.co.uk/what-is-ndvi/
Many applications within food: 
e.g. Nut sorting, laboratory testing of different food products

https://thespoon.tech/impactvision-raises-1-3m-to-combat-food-waste-with-hyperspectral-imaging/
http://www.icef11.org/content/papers/mfs/MFS1281.pdf
https://resonon.com/applications
Do you need Hyperspectral Imaging?

In many cases, Hyperspectral imaging can be used to define the relevant spectral bands!
Do you need Hyperspectral Imaging?

In many cases, Hyperspectral imaging can be used to define the relevant spectral bands!
Do you need Hyperspectral Imaging?

Upto 4 bands are enough for many applications!
Multispectral Imaging with Prism Cameras

*Optimize Spectral Channel Width*

**Standard**

![Diagram showing standard multispectral imaging with CMOS 1, CMOS 2, and CMOS 3 channels with wavelengths λ₁, λ₂, and λ₃.]

**Advantage of Prism**

![Diagram showing the advantage of using a prism, with CMOS 1, CMOS 2, and CMOS 3 channels aligned with wavelengths λ₁, λ₂, and λ₃.]

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Multispectral Imaging with Prism Cameras
Optimize Spectral Channel Width
Examples of multispectral imaging with prism-based cameras

Inspection of potatoes

Fruit/Vegetable Sorting
Examples of multispectral imaging with prism-based cameras

Plant health & growth monitoring using on-ground or drone systems

Red edge detection

Lice on salmon skin

Salmon lice inspection
Examples of multispectral imaging with prism-based cameras

Fruit & vegetable inspection

Operation Tool guidance systems
JAI Color Imaging Portfolio

All technologies available from one supplier

AREA SCAN CAMERAS

- **APEX**
  - R-G-B
  - 3 Sensors

- **FUSION**
  - Bayer RGB/NIR
  - Monochrome
  - Dual Sensors

- **SPARK**
  - Bayer RGB
  - Monochrome
  - Performance

- **GO**
  - Bayer RGB
  - Monochrome
  - Compact

LINE SCAN CAMERAS

- **SWEEP+**
  - R-G-B + NIR
  - New Life
  - Science Models
  - New models with CMOS, high resolution, high speed and 3 sensors

- **WAVE**
  - SWIR (InGaAs)
  - Dual SWIR

- **SWEEP COLOR**
  - Tri-linear

- **SWEEP MONOCHROME**
  - Monochrome
  - New models with 10GigE/SFP+

- **NEW**
  - New models with RGB+NIR & 10GigE/SFP+
THANK YOU
for seeing the possibilities

Jochen Braun

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