Object Detection and Dataset Labeling Using Colors of Manufactured Objects

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Functional Coatings - Object Recognition

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Coatings – We are the Leader In Color Design

2021 embedded VISION summit

Global color collection

Annual trend book

Global design support

Innovative color concepts

Key success factors:

- **Trend research**
  Excellent trend research and visualization
- **Global color collection**
  Translation of trend research into annual global color collection
- **Innovative color concepts**
  New inspiring color concepts with future-oriented approach
- **Global design support**
  Close to the customer all around the world

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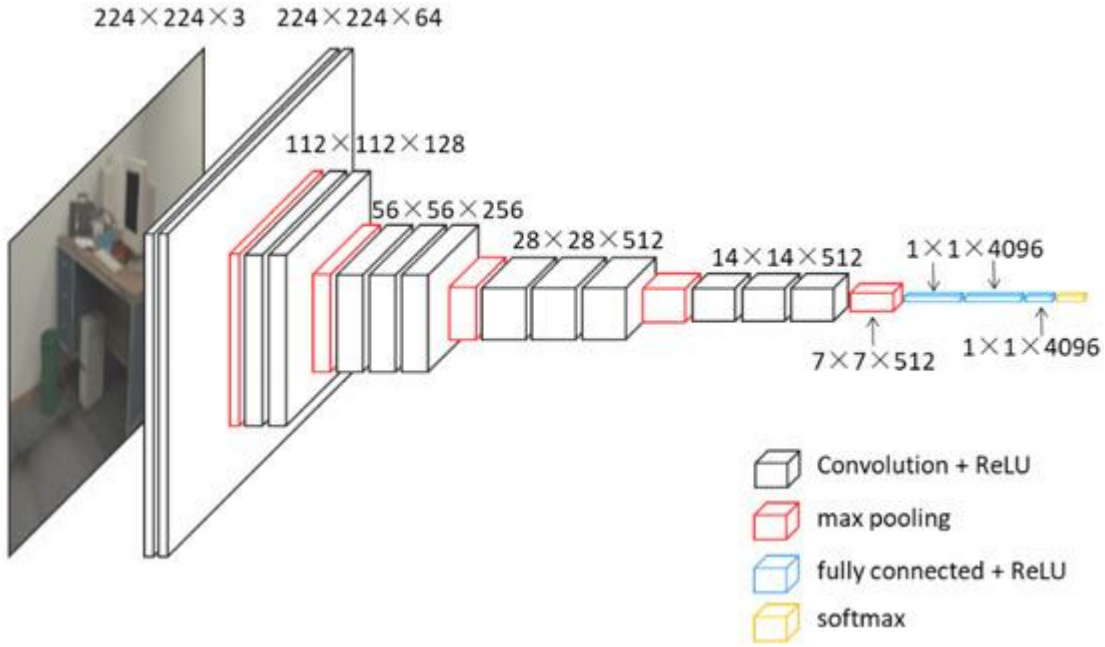
Object Detection with CNNs

- Convolutional neural networks learn features and how the presence and arrangement of the features correlate to classes
  - Large numbers of items, almost infinite arrangements and views, different illumination
  - Lots of great work at solving these issues



Remaining Problems

1. High quality, labelled training image sets are time consuming and expensive
2. AI predictions are less useful when the use case requires more certainty

Figure from: Chen, Y.; Chen, R.; Liu, M.; Xiao, A.; Wu, D.; Zhao, S. Indoor Visual Positioning Aided by CNN-Based Image Retrieval: Training-Free, 3D Modeling-Free. Sensors 2018, 18, 2692. https://doi.org/10.3390/s18082692

Object Detection Edge Cases

Partial occlusions

Flexible shapes

Pose dependency

Logos on other items

Barcode issues

Real life example

Recycling Bin Top View

Ultimate problem is the lack of a universal ground truth

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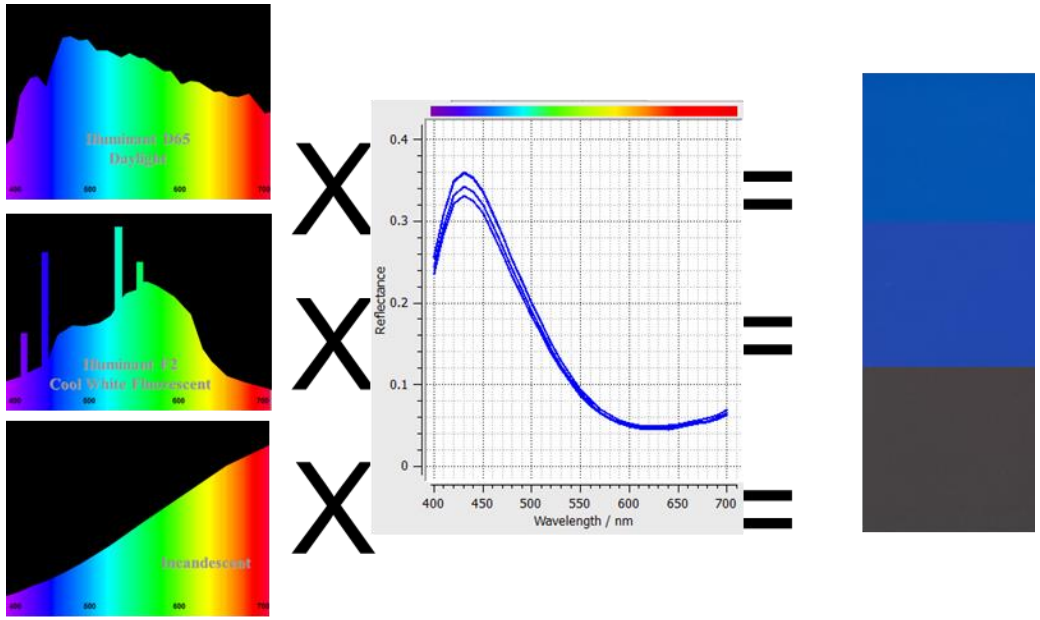
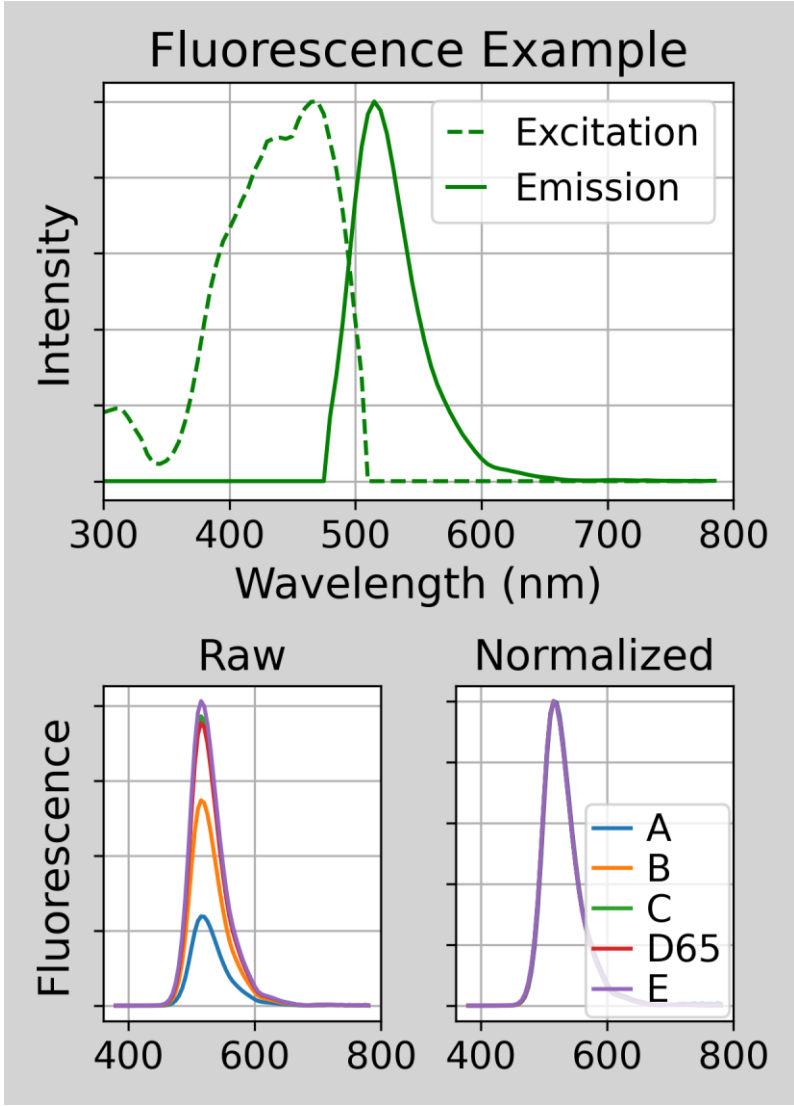
Color and "Ground Truth"

- Color seems like an obvious choice for a ground truth candidate
  - Unfortunately, an object's perceived color is strongly dependent upon illumination
  - We really want an easy measurement an object's reflectance curve- it's inherent colorfulness

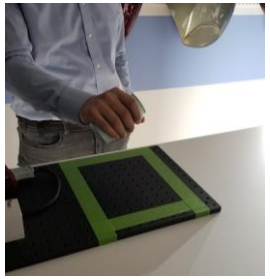


Fluorescent Chroma

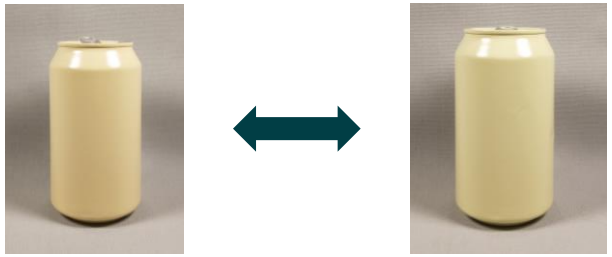
- Fluorescence is the absorption of light at one energy and emission of light at another energy (ex. blue→red)
  - Magnitude of emission changes but shape (chroma) does not under different illumination
  - Ideal “ground truth” IF you can separate from reflectance
- BASF has developed fluorescent coatings and camera/lighting designs to extract the fluorescence chroma and use it for object detection, classification, and segmentation



Examples of Fluorescent Objects



3D shapes



Similar colors, different color IDs

- Commercial articles
  - Plastics
  - Printed packages
  - Fabrics
- Printable labels
  - Post-production solution (similar to an added price sticker)
- Custom coatings

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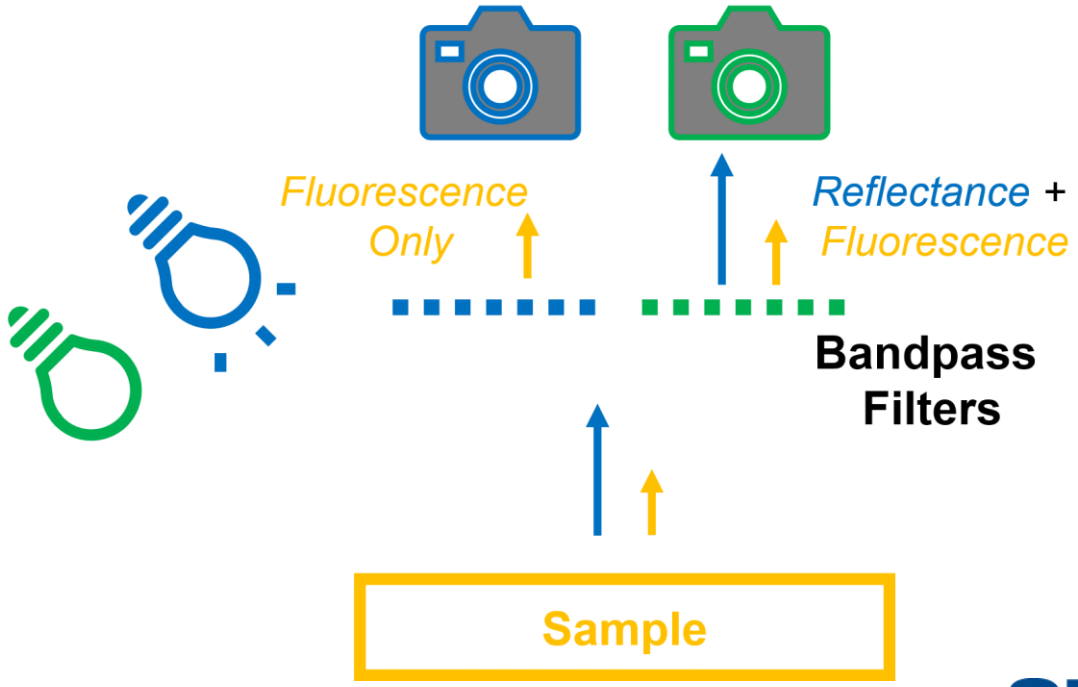
System Design

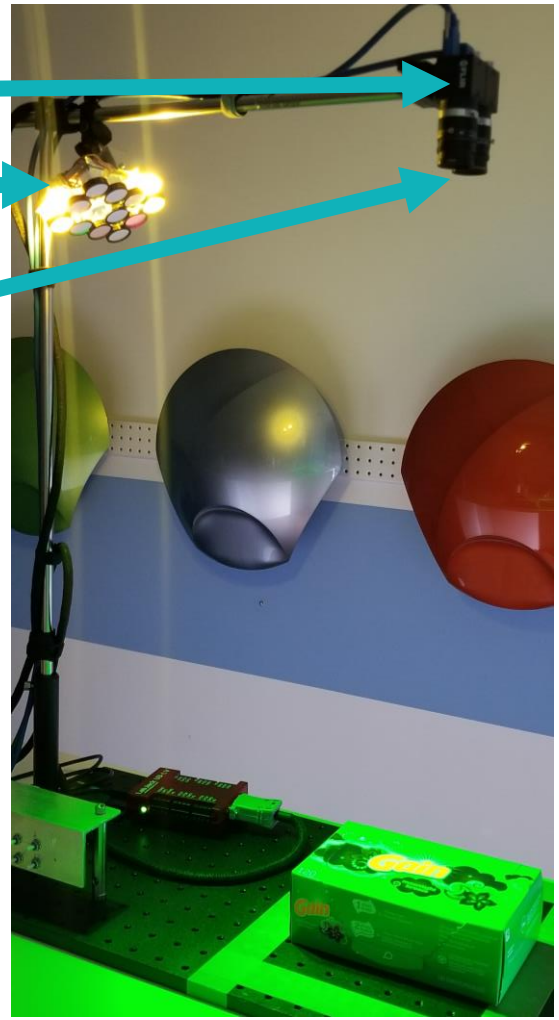
Basic idea: block reflective light from reaching camera



Cameras

LEDs

Bandpass Filters



System designed in partnership with SRI International

System Operation

Capture speed

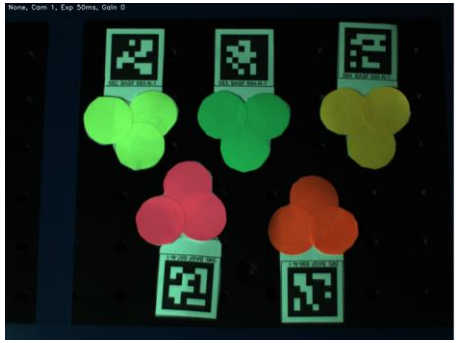
Classification demo

Classification Model and Accuracy

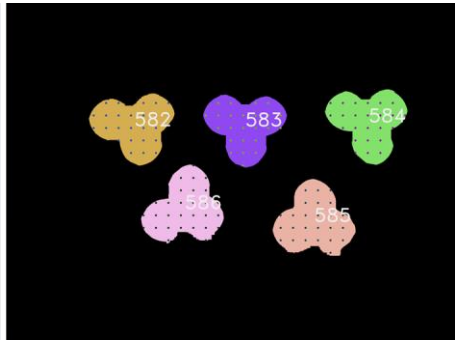
- Can use many models for classification, but nearest neighbors with neighborhood component analysis works well
  - Fluorescence segmentation is part of preprocessing
  - Best results with all channels, fluorescence doing majority of work
  - Some LEDs are better than others, both cameras are better than either one

# LEDs	Camera #	Channel	Pixel Accuracy	Accuracy Rank	Object Accuracy
6	1,2	all	0.957	1	1
4	1,2	all	0.946	4	1
2	1,2	all	0.885	8	0.996
2	2	all	0.869	9	0.989
2	1	all	0.766	17	0.95
8	1,2	fluorescence	0.864	10	0.966
10	1,2	reflectance	0.62	20	0.765

280 classes, different lighting conditions for training and testing



Reflective Image



Fluorescent Segmentation

Use Cases and Partnerships

Visual AI Training

As is: Manual image labelling slows whole pipeline

Collect images → Determine labelling criteria → Manually label images → Train CNN → Deploy → Update & retrain → Deploy

To be: Color Detect automatically labels images, increasing workflow rate and retraining speed

Color Detect articles → Collect images → Label with Color Detect → Train CNN → Deploy → Update & retrain → Deploy

Retail

Get in touch (colordetect@basf.com) if you think Color Detect technology could help your business or project!

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Conclusions

- Fluorescent chroma can be separated from reflectance
- Fluorescent chroma can be used to improve object classification and segmentation model performance
- Applications in retail, visual AI model training, and more

Thank you!

Resource Slide

https://www.colordetect.basf.com

https://www.edge-ai-vision.com/companies/basf/

2021 Embedded Vision Summit

Color based Object Detection System for Visual AI Applications Demo