Looking Ahead

Clubes de Ciencia - Ensenada 2017

Frank Wilzcek Course

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Conventional Hyperspectral Applications

Hyperspectral Applications - Agriculture

Assessing plant health, monitoring (+ controlling?) light environment.

Hyperspectral Applications - Agriculture

Spectral Image Analysis for Measuring Ripeness of Tomatoes

G. Polder, G. W. A. M. van der Heijden, I. T. Young

Wavelengths used: 396-736 nm

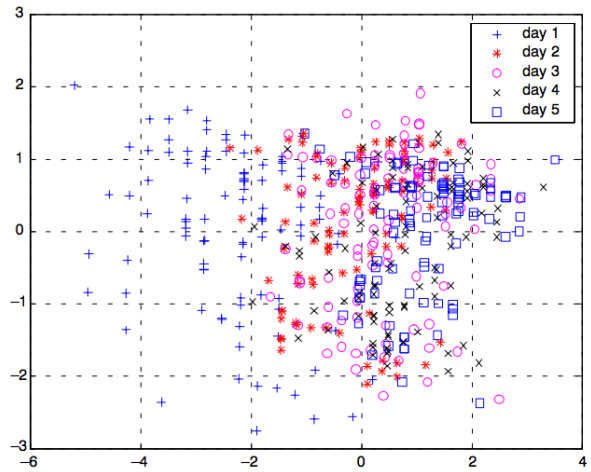


Figure 3. Scatter plot of the first and second canonical variables of the LDA analysis of the RGB images. Classes 1 to 5 represent the ripeness stages of tomato B during the five days after harvest, respectively.

Consumer Camera ←

Hyperspectral Camera →

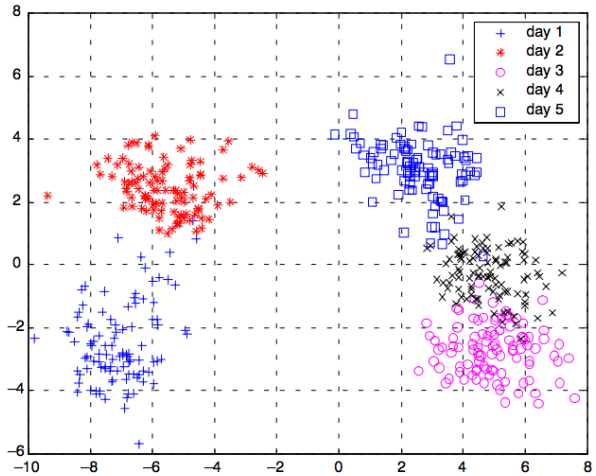


Figure 4. Scatter plot of the first and second canonical variables of the LDA analysis of the spectral images. Classes 1 to 5 represent the ripeness stages of tomato B during the five days after harvest, respectively.

Hyperspectral Applications - Art and Archaeology

Determining the nature of pigments and materials, finding under-paintings.

Hyperspectral Applications - Biology

MUSE (Microscopy with UV Surface Enhancement) image of colon

Determining the absorption patterns of dyes, notably including fluorescent proteins.

Hyperspectral Applications - Food

Inspecting food sanitation before being sent to the consumer.

Hyperspectral Applications - Forensics

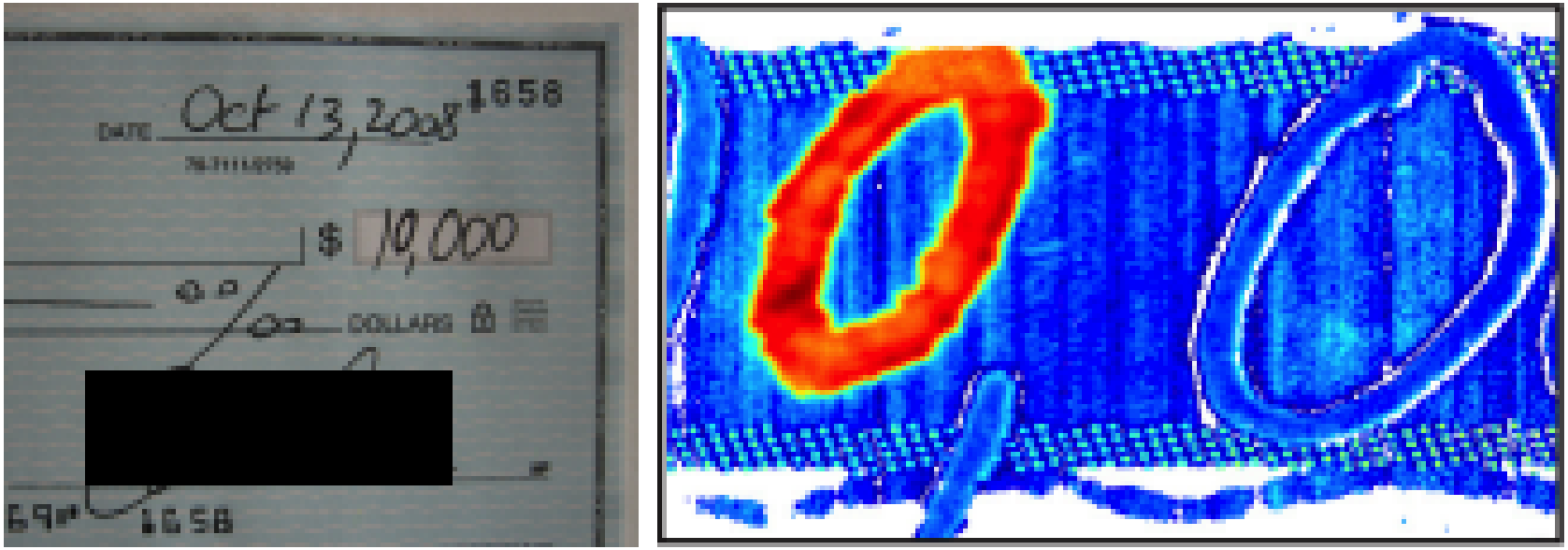


Photo and PCA processed VNIR hyperspectral image of an altered check, indicating very good discrimination of the zero added with a different ink

Finding faulty checks or other (bio) markers that could be used as evidence.

Hyperspectral Applications

- There are also opportunities for artistic creation and display.
- For example, how about movies showing:
  - Hyperspectral sunrises, sunsets and fireworks?
  - Hyperspectral rainbows (and multi-rainbows)?
- Or how about routinely experiencing the world - or an art museum, or virtual reality - in an enhanced way, through appropriate goggles, smartphone display, or illumination?

Hyperspectral Applications

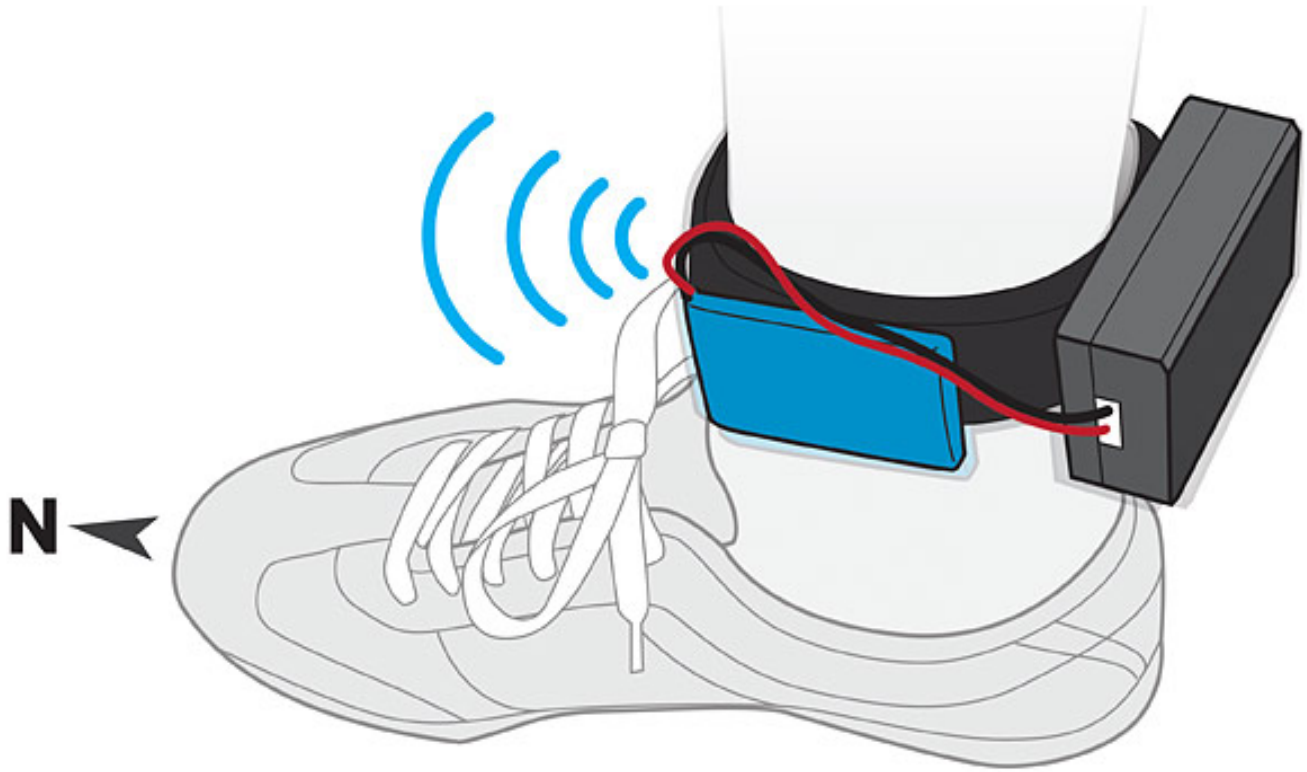
- "I can't escape the feeling that the best ideas are yet to come." - Frank Wilczek
- "Those ideas may/will come from YOU guys!" - Me :)

Other Encodings

- This course has mainly focused on vision and hearing, but there are many other ways of sensing the world.
- In your future explorations, for example in designing useful devices or understanding animal behavior, you might want to think about other sensory possibilities.
- For example . . .

Other Encodings

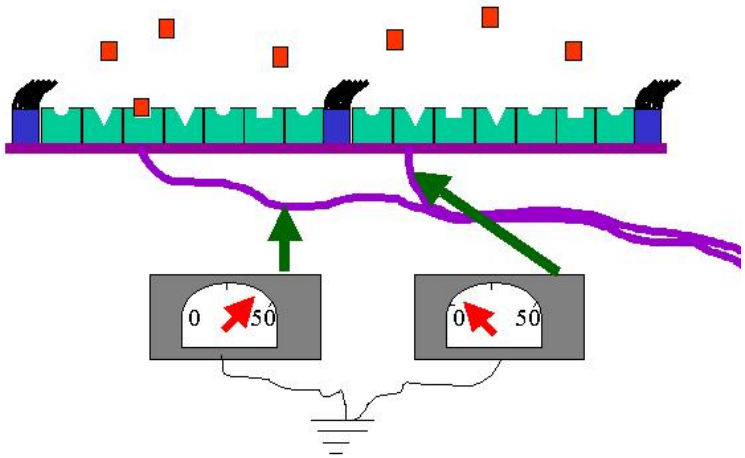
- The “North Paw” sensor vibrates when youâĂŹre facing north. (This device caught Frank’s imagination, and first got him thinking about enhanced perception ...)

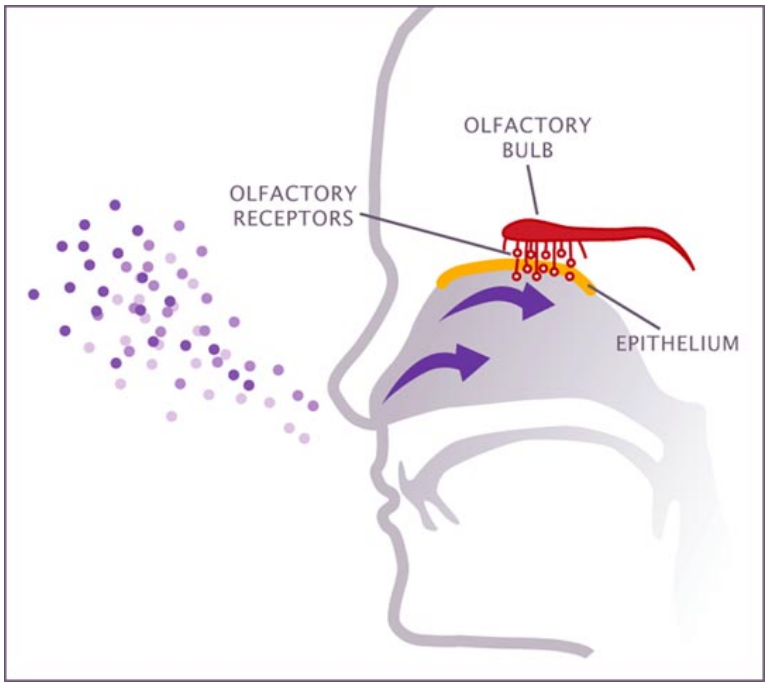


- People have also “restored” a weak form of vision to blind people in this way.

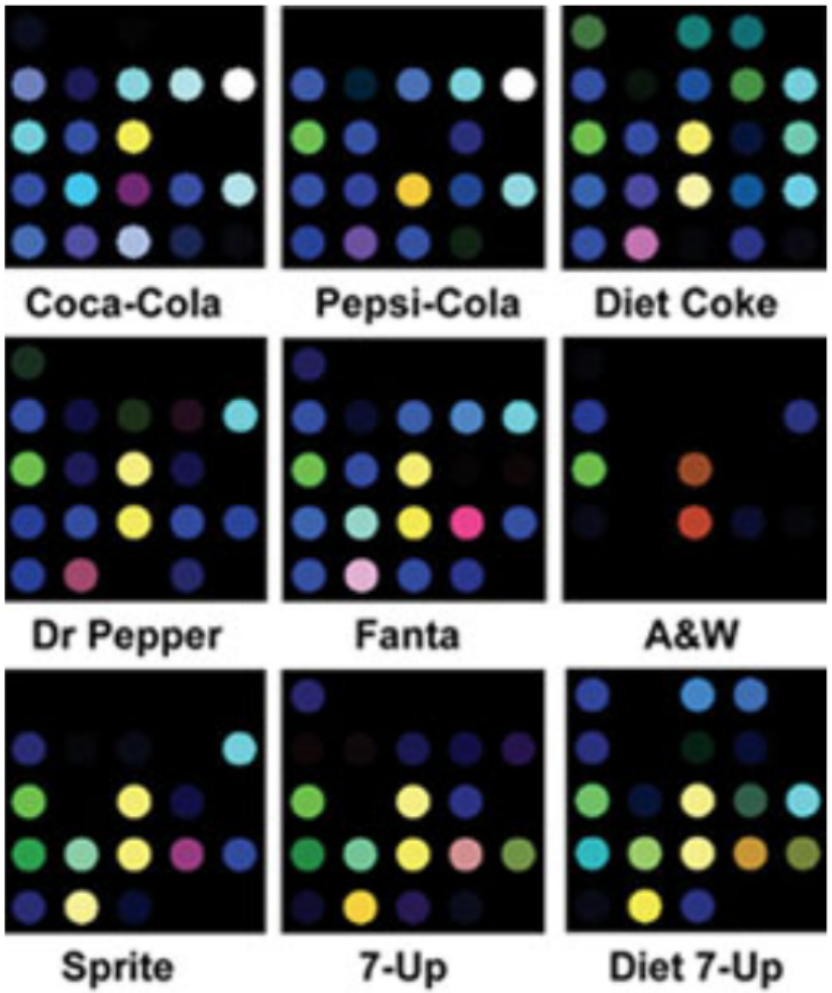
Other Encodings

- Smell and taste are chemical senses. Roughly speaking, their receptors key in on shapes of molecules.
- One can design digital chemical sensor arrays, with visual (or audible) output. There are many options for what is sensed, and how to display it.





Other Encodings



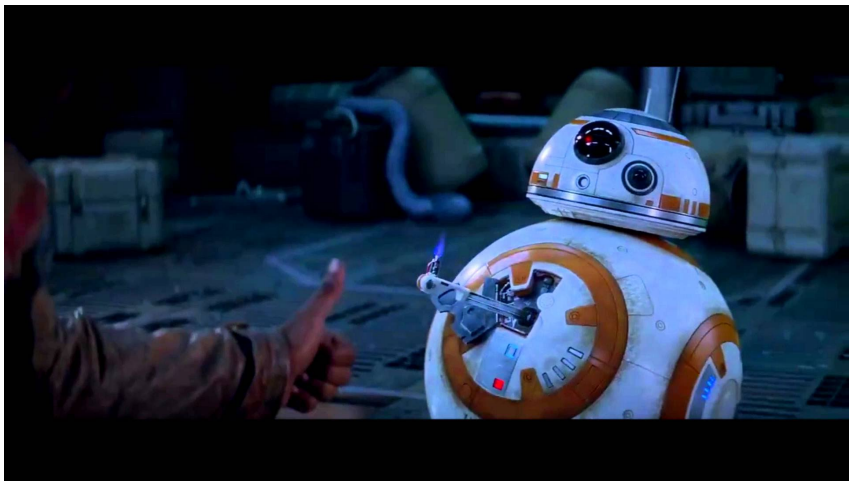
Outputs from an artificial chemical sensor array

Other Encodings

- This design accommodates a combinatorial explosion: with M locations, each allowing k colors, we have k^M possible patterns.
- With $k = 2$ (on/off) and $M = 24$, we have over 16 million possibilities.
- Note that patterns that have a lot in common represent things that have a lot in common, encouraging associative memory.

Other Encodings

- Other possible sensory modalities include: force-detectors and motion-detectors
  - Pressure and vibration detectors
  - Temperature detectors (including infrared vision)
  - Electric and magnetic field detectors
- Any of these might be built into remote sensors, or robots.



- Then an issue is how to present the information to humans, whose most capable portals are visual (especially) and aural.
- Our tricks can be helpful in that regard!

Summary and Conclusion

Summary and Conclusion

- There's a lot more "out there" than we ordinarily perceive.
- Modern technology is opening up important opportunities to perceive more, which can be fun, useful, and not necessarily expensive or impractical.
- We've tried to give you some tools to think intelligently - and creatively - about those opportunities.

Now go make the world a better place!

Picture Citations

CdeC logo (accessed 13 July 2017): https://www.clubesdeciencia.mx
UABC logo (accessed 13 July 2017): http://www.uabc.mx/
Agriculture (accessed 19 July 2017): http://www.nexuscorp.com/controlled.asp
Tomatoes (accessed 19 July 2017): http://wonderopolis.org/wp-content/uploads/2016/04/dreamstime_xl_20359776_(Custom).jpg
Wall painting (accessed 19 July 2017): http://aeronics.in/distribution/multispectral_camera
Check Fraud (accessed 19 July 2017): http://www.middletonspectral.com/applications/other-applications/forensics/
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Smell with shapes (accessed 21 July 2017): https://aqfi.uaex.edu/people/faculty/akelly/z-agoodwin-and-files/Web-Files/Delete/BIOF%20Web%20page%202011/Text/12%20taste%20and%20smell/Tastsm15.htm
Nose (accessed 21 July 2017): http://easysciencefor kids.com/whats-that-smell-all-about-your-sense-of-smell/
BB8 (accessed 21 July 2017): https://i.ytimg.com/vi/_RWWKFqv7EM/maxresdefault.jpg