Novel Data Collection Technique Using Smartphone Camera for Image and Spectrum Analysis

Student: Md Kamrul Hasan, Richard Love, MD, Advisor: Sheikh Iqbal Ahmed, PhD

MSCS Department, Marquette University, USA

Introduction:

Hemoglobin level monitoring is a big challenge for:

- Anemic patients
- Older people
- Premature babies

Reason: Finger-prick or venous blood sample

What we need: Accurate, cost effective, portable and user-friendly noninvasive solution.

Significance:

Mobile Health (mHealth) technology is very useful here since mHealth system has been used for long time as a tool for

- Heart rate monitoring, sleep monitoring, telemedicine, point of care tool, e-ESAS, breast cancer care, and palliative care etc.
- The smartphone camera is one of the important inbuilt sensor with the device.

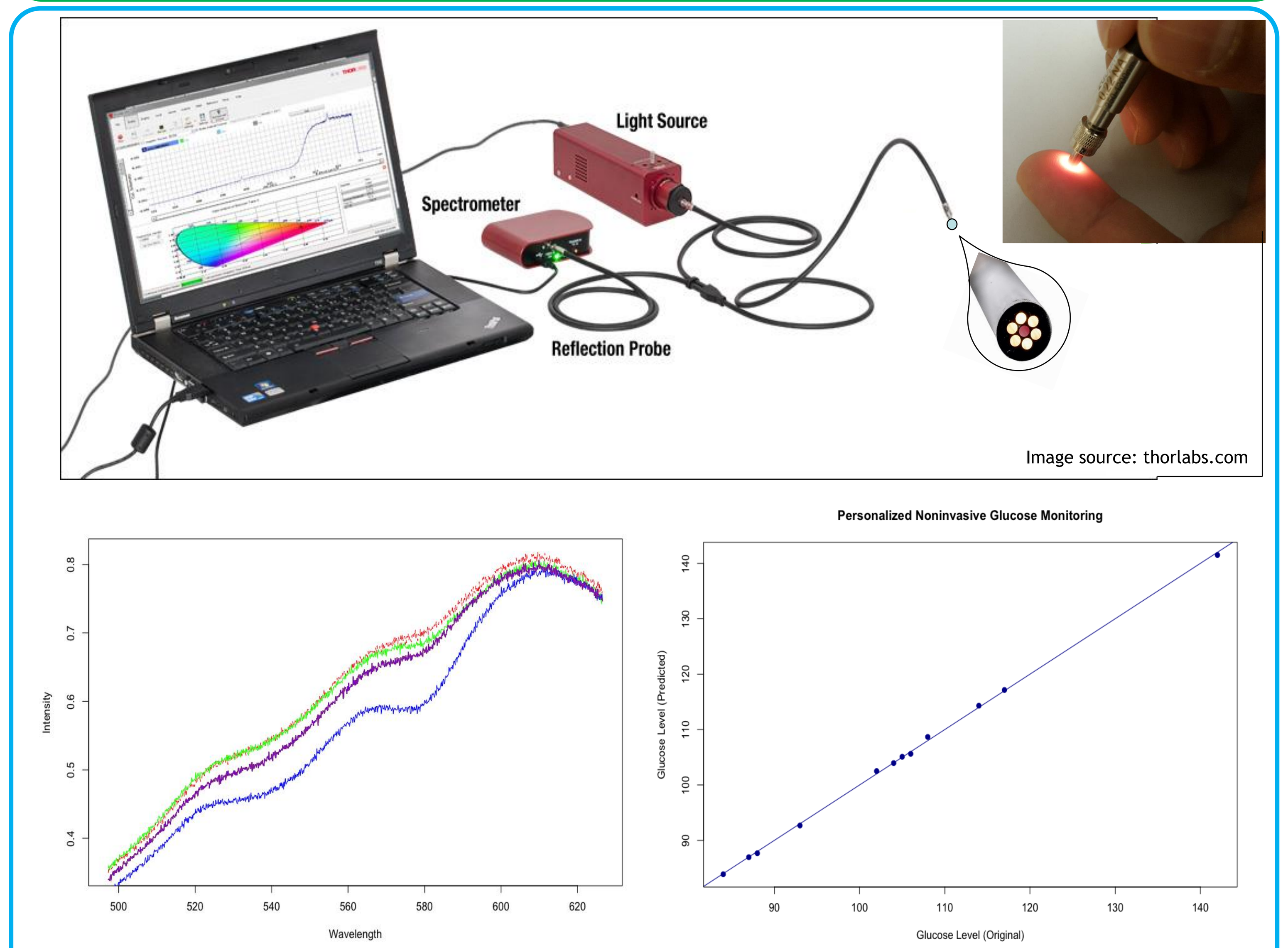

Fig. 1: Spectrum data has been collected using Thorlabs CCS-100 spectrometer. Spectrums are analyzed using PLS algorithm

Methodology:

Current:

- We have collected 12 samples of Glucose level and respective finger spectrum of a single person.
- We have presented the linear regression line of predicted vs lab-Glucose value in the figure here.
- The partial least square method is applied on reflection spectrum.

Proposed Method:

- We are planning to use reflection spectrum for Hemoglobin level prediction using smartphone.
- We collect the video of the finger under red, green, blue and white light (Figure 4, 5, 6,7)
- We have shown the color map of image extracted from four different video of the finger under four different light.
- We are trying to produce the reflection spectrum from these image.
- We can adopt the compressive sensing algorithm [1]
- Brian Smits has shown the RGB to reflection spectrum in his research [2].
- Partial least square and support vector machine algorithm is preferred for the data analysis.

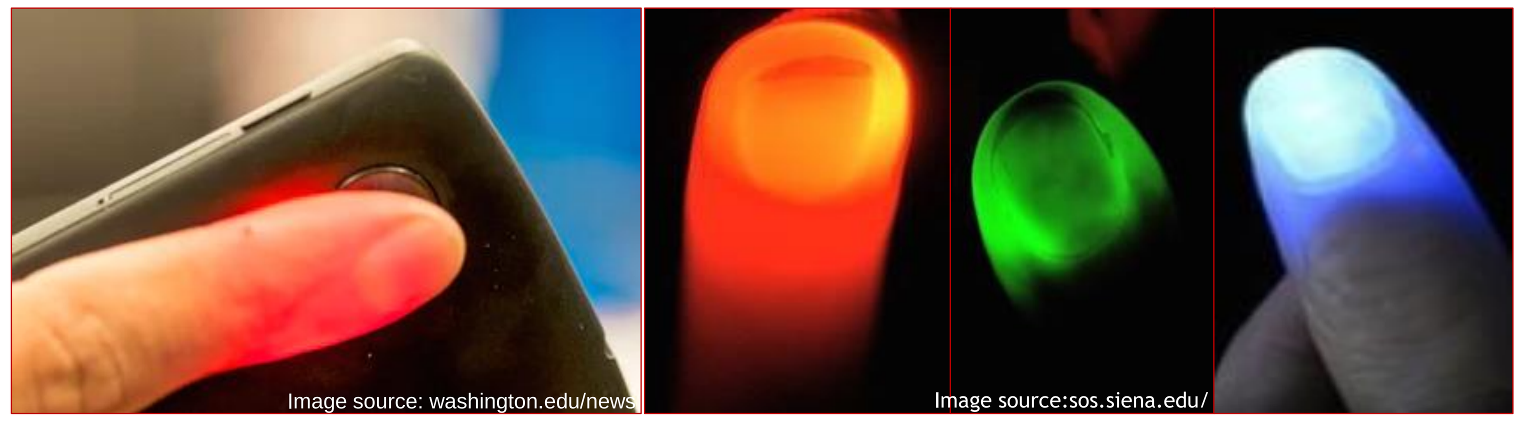

Fig.2 : Index finger is put on the smartphone camera having the mobile flash on. We have used red, green, blue and white light to enlighten the finger externally for each video.

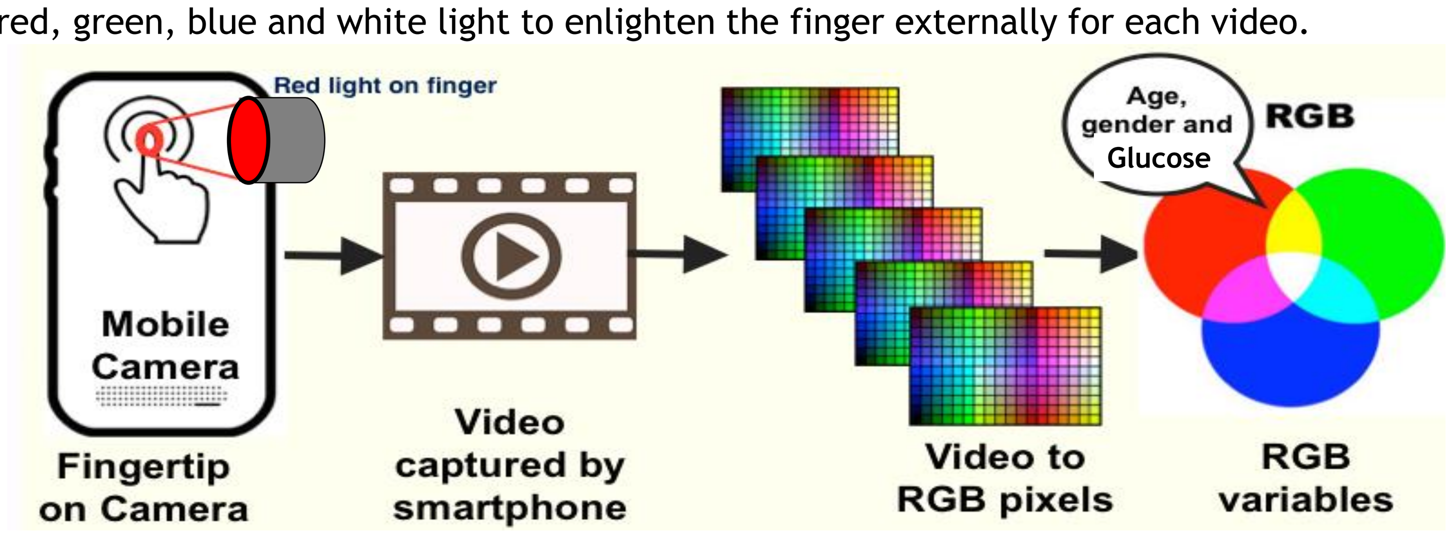

Fig. 3: Finger video is captured for 10 seconds. Frames are extracted from each video and red, green and blue pixels are separated for color map.

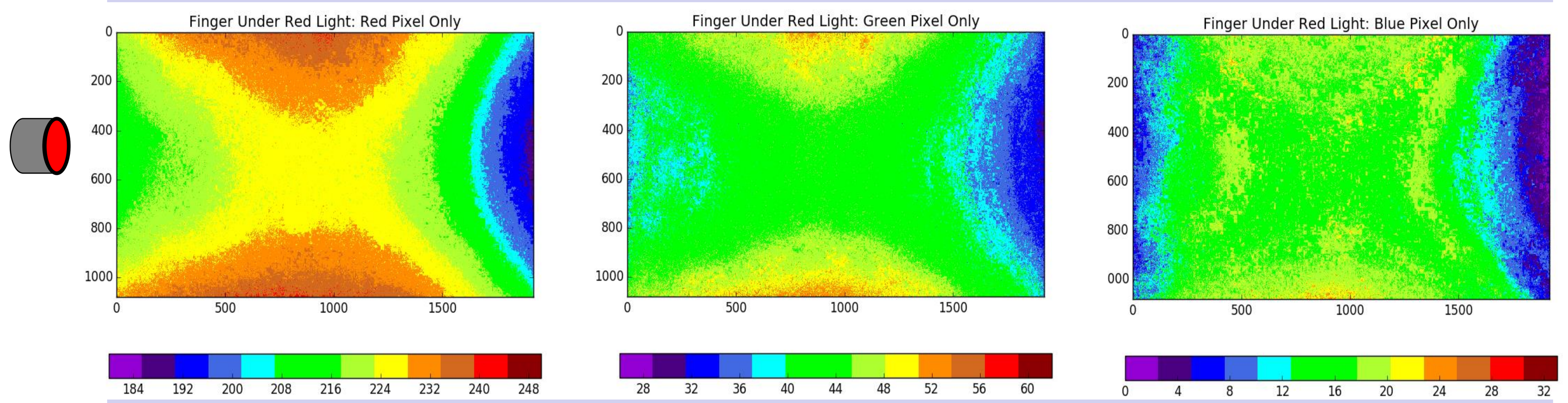

Fig. 4: The image under red light is taken and red, green, blue pixels are mapped in these three pictures.

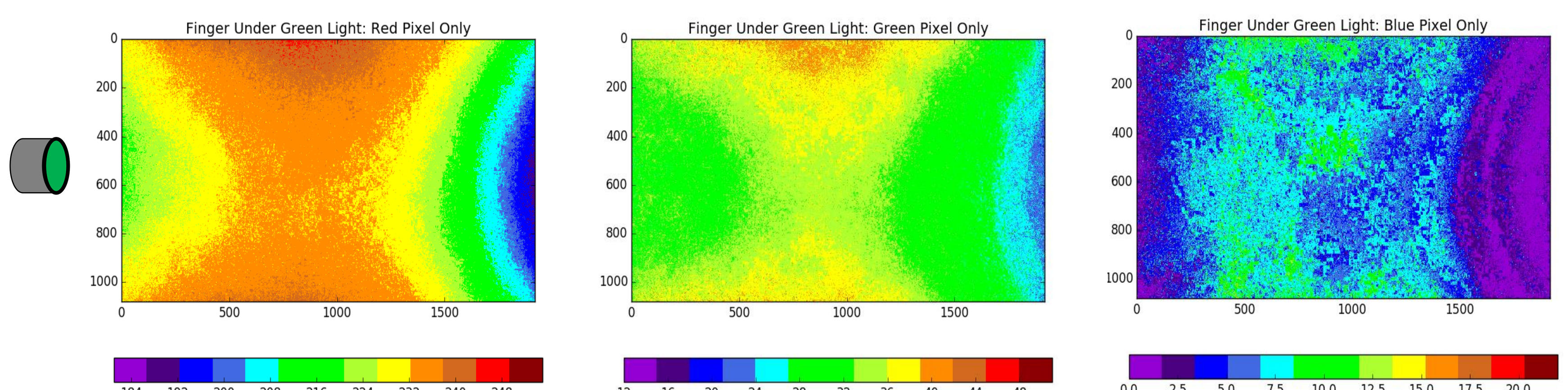

Fig. 5: The image under green light is taken and red, green, blue pixels are mapped in these three pictures.

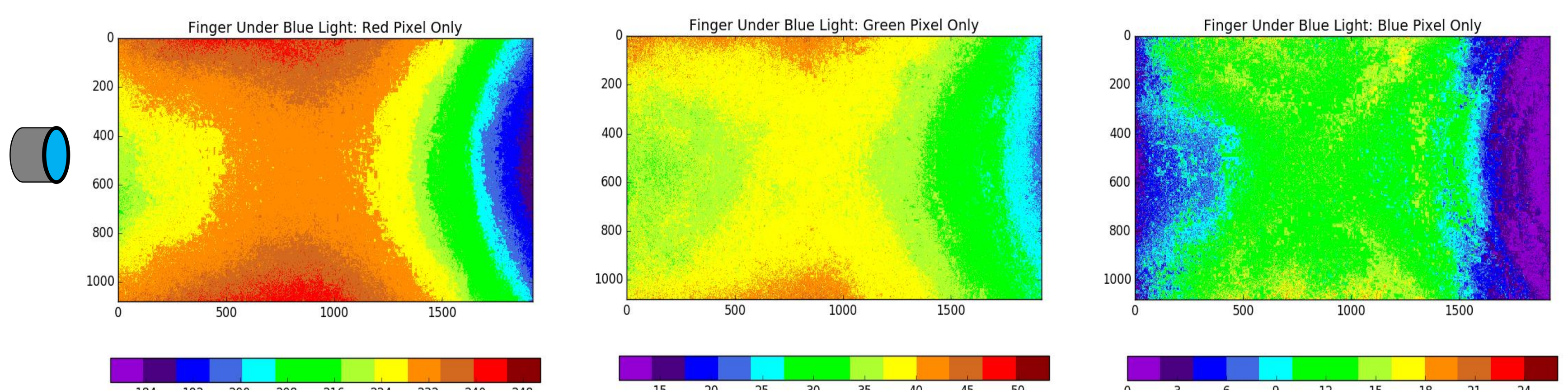

Fig. 6: The image under blue light is taken and red, green, blue pixels are mapped in these three pictures.

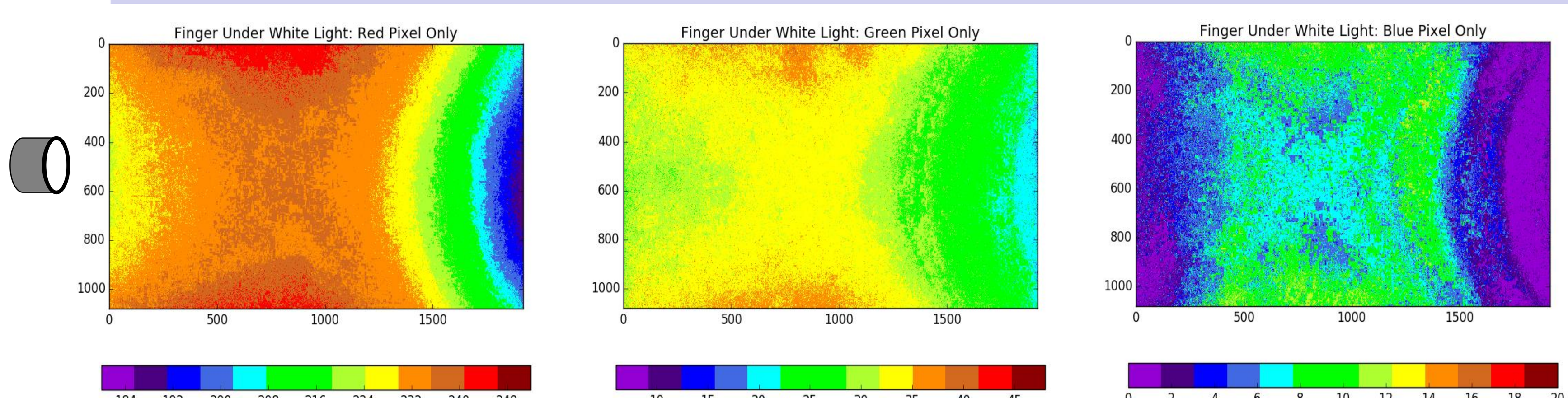

Fig. 7: The image under white light is taken and red, green, blue pixels are mapped in these three pictures.

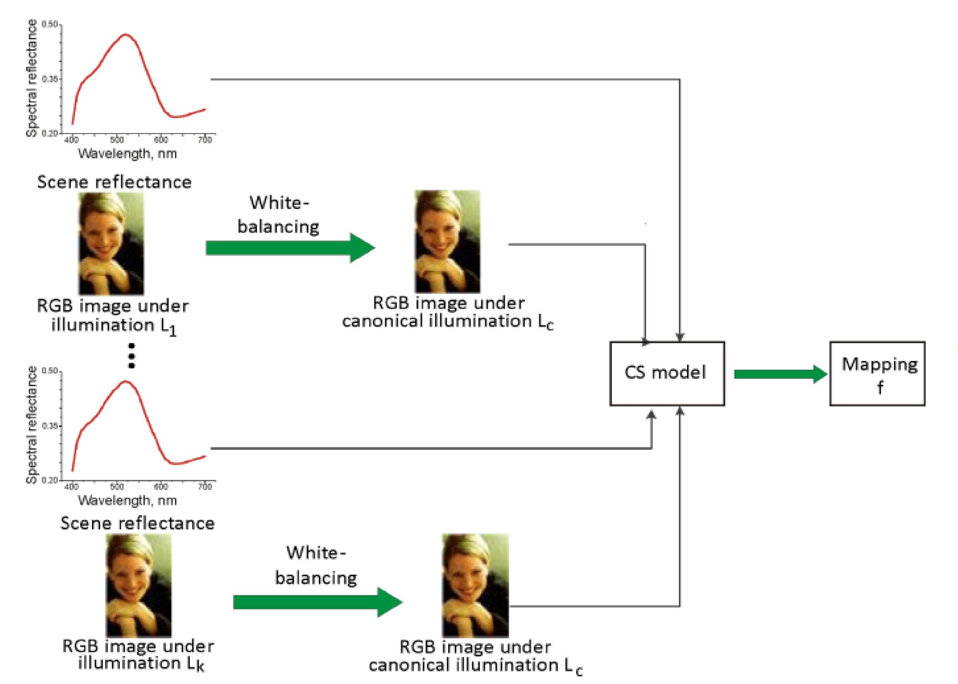

Fig. 8 Mapping relationship between the RGB image and the spectral reflectance [1]

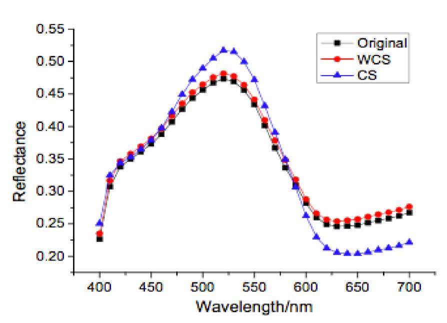

Fig 9: Comparison of results obtained with different spectral reflectance reconstruction algorithms [1].

Zhang et al. has presented a process to convert RGB pixel to reflection spectrum in their research paper [1]:

1. They have developed a series of modulated light sources
2. They used RGB camera to capture multi-channel spectral images.
3. Six-channel digital response is calculated using three different color filters.
4. The basis function vector is obtained using the principal component analysis.
5. The compressive sensing algorithm is used for mapping function

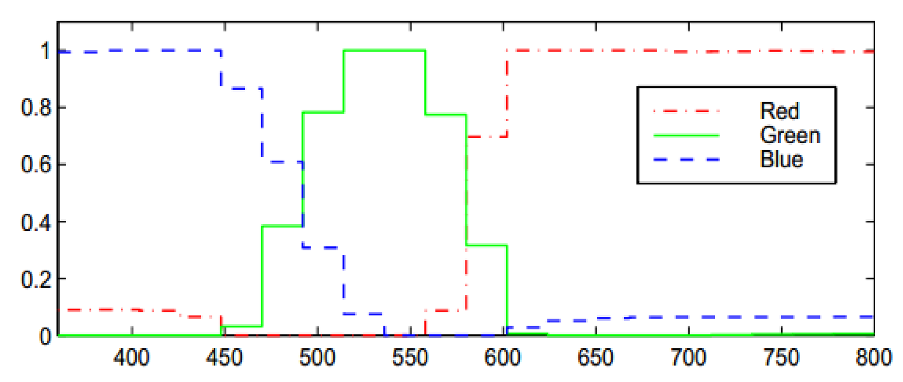

Fig. 10 The spectra for red, green, and blue. [2]

```
Spectrum RGBToSpectrum(red,green,blue)
  Spectrum ret = 0;
  if(red ≤ green && red ≤ blue)
    ret += red * whiteSpectrum;
    if(green ≤ blue)
      ret += (green - red) * cyanSpectrum;
      ret += (blue - green) * blueSpectrum;
    else
      ret += (blue - red) * cyanSpectrum;
      ret += (green - blue) * greenSpectrum;
  else if(green ≤ red && green ≤ blue)
    ⋮
  else      // blue ≤ red && blue ≤ green
    ⋮
```

Brian Smits has been shown his reflection spectrum development technique in his research work [2].

1. His method look for the metamer space for a spectrum to best fit the set of criteria.
2. The technique uses the blue value for the first n coefficients, the green value for the next n , and the red for the last.
3. Basis functions were constrained to be a multiple of 3.
4. The considered spectra was defined over the interval from 400 nm to 700 nm

Conclusion:

1. We presented how reflection spectrum gives good prediction level
2. We have also shown the different image color map where each image is captured under different color of light.
3. We are approaching some techniques to produce reflection spectrum from RGB image captured by smartphone.

[1] Leihong, Zhang, et al. "Spectral reflectance recovery from a white-balanced RGB image based on the algorithm of compressive sensing." *Ukr. J. Phys. Opt* 17.3 (2016): 113.

[2] Smits, Brian. "An RGB-to-spectrum conversion for reflectances." *Graphics tools: Te jgt editors' choice* 291 (2005).

Contact: Md Kamrul Hasan, Email: mdkamrul.hasan@marquette.edu