Palette: Enhancing E-Commerce Product Description by Leveraging Spectrophotometry to Represent Garment Color and Airiness

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CHI'15 Extended Abstracts, Apr 18-23, 2015, Seoul, Republic of Korea
ACM 978-1-4503-3146-3/15/04.
http://dx.doi.org/10.1145/2702613.2732860

Figure 1. We propose *Palette*, a method to quantize material color and airiness (i.e. clothing ventilation) to provide objective representation of a product.

Abstract
We present *Palette*, a method to objectively quantize material color and airiness to provide representative description of a product in online shopping scenarios. Photos and keywords are often used to describe color, texture, and airiness of products. However consumer photos are usually taken under uncontrolled realistic imaging conditions, whereas keywords are fuzzy and highly subjective. *Palette* leverages active spectrophotometry approach that involves synchronized illumination to measure the reflection and transmission properties of a material as a function of wavelength.

We use a Charge-Coupled Device (CCD) sensor equipped camera to capture visible light and near-infrared light intensity. We show that by analyzing the obtained light spectrum, we are able to provide a metric to represent material color and airiness. In this paper, we describe the details in principle of operation and proof-of-concept prototype implementation, as well as reporting results of our analysis using 4 types of garments. To the best of our knowledge, *Palette* is the first work to exploit spectrophotometry to represent garment color, texture, and airiness; as an effort to enrich user experience in online shopping.

Author Keywords
Material color, texture, and airiness; spectrophotometry; active illumination; product description; e-commerce.

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation (e.g. HCI): User Interfaces.

Introduction
Material color and texture effects are highly relevant aesthetic features of garment and textiles, which have strong impact on costumers' perceived quality of a product. To the best of our knowledge, there is no well-established method that offers an objective, reliable, lightweight, and mobile solution to quantitatively represent a combination of color and texture for garments. This issue poses serious challenges especially in related e-commerce industry such as clothing, fashion, furniture, and so on. In common practice, human operatives perform the identification of color and texture by means of visual and/or touch inspection. As a consequence, the inspection is performed in a qualitative and unreliable way; thereby the definition of a method for the automatic and objective inspection is necessary. Also, the lack of objective metrics to represent textures causes extensive usages of subjective words and phrases in product descriptions, e.g. soft and transparent, suede-like, toweling, etc. Costumer often become confused by these descriptions and hesitated on buying clothes online. Moreover, misleading product descriptions potentially cause costumer to return the delivered merchandise due to mismatched expectations. Overall, this may cause bad user experience and pose negative marketing for merchants, as well as increase operational costs.

We introduce *Palette*, a method to objectively quantize material color and airiness to provide representative description of a product in online shopping scenarios. On the basis of the state of the art in spectrophotometry, the present work aims to describe a computer-based approach for objective inspection of color and texture effects on garments, resulting in robust color matching that mitigates effects of ambient lighting, and classification of garments into pre-trained classes of textures. Actual usage of *Palette* is depicted in Figure 1. The devised apparatus is composed by hardware part that implements active illumination based spectrophotometry using a camera with CCD sensor, and a series of software implementation for spectrum analysis. *Palette* is able to determine the definitive color of a material by observing light intensity of a range of wavelength, which varies as a function of reflections or transmission properties of a material. These signals form a material entropy curve that serves as basic for our color matching and airiness analysis.

In this paper, we contribute to Human-Computer Interaction (HCI) and Ubiquitous Computing (UbiComp) community by presenting *Palette*'s principle of operation, prototype design and implementation, as well as proof-of-concept applications and evaluation. We also discuss limitations, and share our plan for future iteration of this work.

Related work

To the best of our knowledge, there is no previous work that explicitly explores usage of spectrophotometry for material color and texture inspection purposes. However, a number of research and commercial products have been proposed to provide partial solutions of the issues we have presented in previous section. Computer Vision (CV) based methods for color matching from parts of an image captured using camera are among the popular [1,2,3]. Our approach share common motivation in providing lightweight solution, and furthermore seeks to extend robustness to environmental illumination by incorporating not only visible light spectrum but also near infrared through CCD sensor. Exploitation in deeper semantics of color description keywords for online clothing search has been proposed [4]. Although proven to be feasible, Natural Language Processing approaches still pose limitations when exposed to different language or culture. Realizing this issue, an effort to build a large dataset based on Mechanical Turk for texture identification has been conducted [5]. This work encourages us to provide objective metrics for texture database.

Hardware based approaches such as surface texture estimation based on friction has also been proposed [6]. This approach leverage distributed strain gauges and polyvinylidene fluoride (PVDF) films embedded in silicone-made surface contact. Different textures induce different intensities of vibrations, and consequently, textures can be distinguished by the presence of different frequencies in the signal. Unfortunately, bulky settings and requirement to obtain optimum synchronization of scan distance and its' vibration signal pose challenges in end-user applications. Nevertheless, approaches that incorporate hardware solutions encourage us to explore new features that can help to distinguish color and texture more robustly.

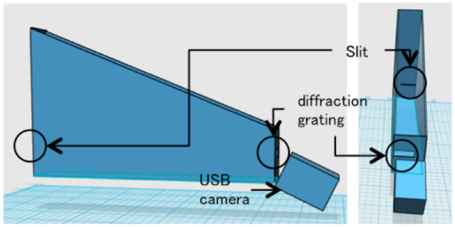


Figure 2. Palette is a system based on spectrophotometry with active illumination, constructed of a diffraction grating and IR-filter stripped USB camera, packed in a 3D print case.

Palette Implementation

Palette consists of two main components, which are diffraction grating for spectroscopy and CCD sensor for detecting light intensity of each wavelength. These parts are placed in a 3D printed case depicted in Figure 2. In our prototype design, we utilized a CCD sensor based USB camera as the light spectrum sensor. We adjusted the lens to make parallel lights so that the optical structure resembles configuration depicted in Figure 3. We capture image from the camera, and to capture the light intensity for a range of wavelength we utilized ImageJ [7], which is an open source image processing program designed for scientific multidimensional images.

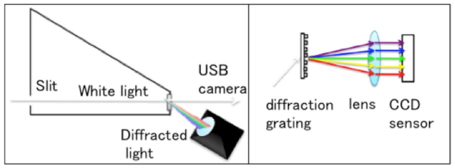


Figure 3. Diffraction grating diffracts incident light, and lens refracts light in parallel manner so that it becomes easier to align on the surface of the CCD sensor.

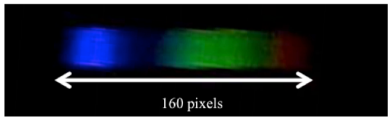


Figure 4. Exemplary spectrum from a cotton towel.

Figure 4 is an exemplary image capture of a spectrum from cotton towel. From end to end, the spectrum is 160 pixels and we measured the intensity of each frequency of light using *plot profile* function. The function converts the points on the spectrum image (indicated as white line) to gray scale, and lists the intensity of each point as value of 0 to 255. The spectrum must be normalized by directly emitting white LED to spectrometer and adjust software to make all wavelength's intensity in the same initial value. This step is important to mitigate hardware-related differences between various types of LED and CCD.

Results

Color Recognition

Materials absorb specific frequency (or wavelength) of lights depending on the color. Therefore, reflected light from material has information on color. Our framework is able to measure each wavelength's light intensity. Therefore, definitive color of the material can be measured and thus, represented in an objective metric.

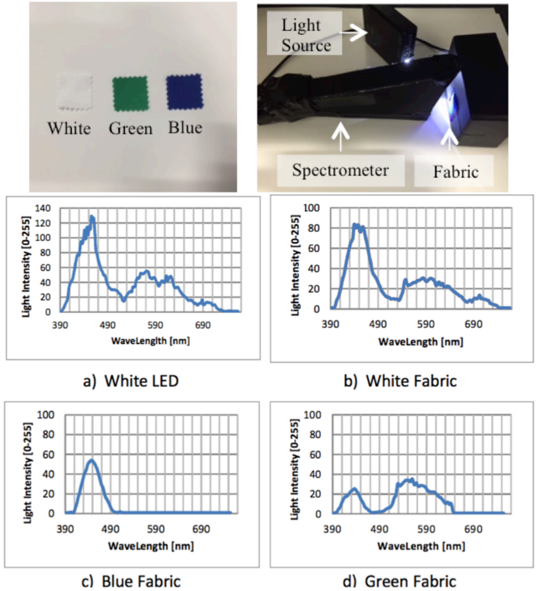


Figure 5. Garment samples used for color matching evaluation with their respective reflected light spectrums.

Figure 5 shows garment samples used for color matching evaluation. We utilized white color LED to obtain correct spectrum of reflected light, due to white LED's wide frequency range. The garment is simultaneously illuminated during the spectrum capturing. It is important to note that the distance between spectrometer and the garment is fixed in our prototype's case design, in order to provide correct measurement of the reflected light's spectrum. These tested garments are fixed at a same position on top of the case, which was made using a 3D printer with black plastic filament. In the experiment, the angle of light source was determined to maximize reflection light from fabric. Figure 5 also shows result on the experiment for recognizing the color on 3 different fabrics: a) is original spectrum of the white LED measured by directly emitting the light to the spectrometer; b), c), and d) are spectrums of reflected light from white, blue, and green fabric, respectively. White fabric refracts wide-range of light frequency. Therefore, the spectrum indicates similar characteristic to illumination's white LED's spectrum. On the other hand, the characteristics of spectrums on blue and green fabric are different from the original illumination. Blue fabric reflects specific frequency for blue (380 to 495nm). Green fabric reflects frequency for blue and green (455 to 630 nm). Hence, this information can be used to accurately recognize color.

Indicator of Airiness

Material texture consists of complex information such as thickness, airiness, and way of fabric knitting pattern. In this subsection, we show that spectrum of reflected right from a fabric can be an indicator to revel texture information. Figure 6 depicts materials used for airiness analysis, which are parts of fabrics that are cut out from socks, towel, and handkerchief. We used the same hardware setup as previous experiment. Figure 6 also shows the result on experiment for analyzing the airiness of fabrics. The amplitude difference on certain range of wavelength depicts the difference of airiness or thickness of the fabric. Hence, provide a key finding to identify fabrics' airiness or thickness.

Evaluation of Airiness

To evaluate the effectiveness of our approach, we analyze the correlations between thickness and airiness of each garment, respective to the spectrum's mean amplitude. Figure 7 depicts our experimental setup and results. To measure ratio of each samples' airiness, we made a simple indicator based on angular difference

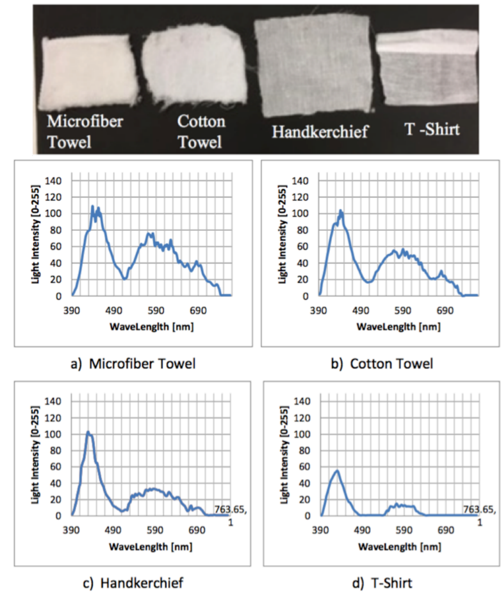
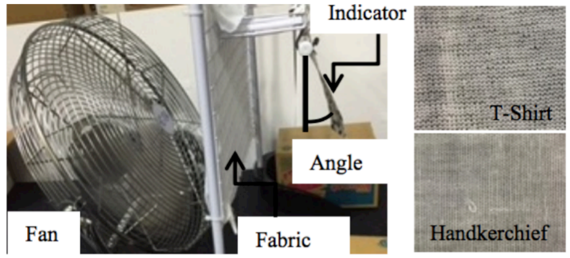


Figure 6. Garment samples used for airiness analysis with their respective reflected light spectrums.

that depends on the air passed through the fabric from a fan that was set to constant rotation-per-minutes (RPM) and we measured the thickness by a measuring instrument. Observable in our result, the spectrum's amplitude was highly correlated with airiness. For instance, even if t-shirt is thicker than the handkerchief, the value of airiness is higher and the mean of amplitude is lower.

Discussion

In this paper, we only describe features on spectrums in visible light. However, spectrums in the range of near-IR have considerable amount of information on texture. For example, polyethylene used for cloth absorbs 2.3μm and 3.4μm of light significantly. By incorporating these kinds of characteristic, we can



Fabric	Thickness	Airiness	mean of amplitude
Micro Fiber Towel	8[mm]	0°	44.9
Cotton Towel	3[mm]	0°	36
Handkerchief	0.2[mm]	10° - 20°	24.2
T-Shirt	0.5[mm]	30° - 45°	9.3

Figure 7. Correlation between thickness, airiness, and the amplitude mean of aggregated spectrums for each samples.

obtain spectral parameters of a garment material. Furthermore, by analyzing light spectrum and aggregating contextual features, we will be able to represent material color and texture in separate nominal classes using supervised training based machine learning. Current design of *Palette* can combine color and texture recognition, however, cannot recognize each of these simultaneously. Additional reference fabrics are necessary to achieve usability level for e-commerce scenario. Also, a hardware design leveraging smartphone-mounted spectrometer is advisable for better mobility and end-user affordance. Several generations of IPhone don't have IR-filter in its front camera. Therefore, we can make similar *Palette* configuration in much simpler way while solving hardware issues, e.g. power source for illumination.

Conclusion and Future Work

We presented *Palette*, a method to objectively quantize material color and texture for providing representative description of a product in online shopping scenarios. We described theory of operations, demonstrated technical feasibility by prototype implementation, and reported our evaluations on color and airiness for different garments. For future iteration of this work, we plan to improve hardware design as well as expand spectrum analysis in time-space domain using wavelets. We believe this will be useful to aggregate richer features to reliably distinguish material textures.

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