# Effects of Environmental Colour on Mood: A Wearable Life Colour Capture Device

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## ABSTRACT

Colour is everywhere in our daily lives and impacts things like our mood, yet we rarely take notice of it. One method of capturing and analysing the predominant colours that we encounter is through visual lifelogging devices such as the SenseCam. However an issue related to these devices is the privacy concerns of capturing image level detail. Therefore in this work we demonstrate a hardware prototype wearable camera that captures only one pixel - of the dominant colour prevelant in front of the user, thus circum-navigating the privacy concerns raised in relation to lifelogging. To simulate whether the capture of dominant colour would be sufficient we report on a simulation carried out on 1.2 million SenseCam images captured by a group of 20 individuals. We compare the dominant colours that different groups of people are exposed to and show that useful inferences can be made from this data. We believe our prototype may be valuable in future experiments to capture colour correlates associated with an individual's mood.

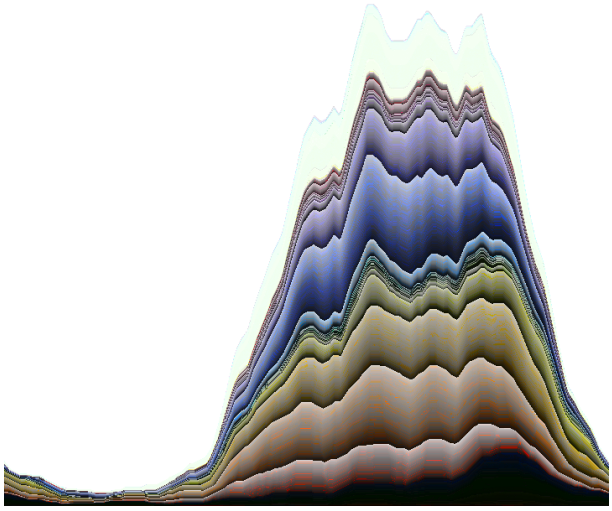

**Figure 1: Typical colours experienced in an average weekday across a group of researchers**

## Categories and Subject Descriptors

H.1.m [**Models and Principles**]: Miscellaneous; H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval; E.m [**Data**]: Miscellaneous

## General Terms

Design, Experimentation, Human Factors

## Keywords

lifelogging; SenseCam; wearable cameras; colour and mood

## 1. INTRODUCTION

The colour that surrounds us in our daily lives has a profound effect on our mood and on our behaviour [1], therefore it may follow that if we could measure it, we may get a clue as to how our mood varies. We know that colours like red, orange and yellow are known as "warm" and blue, green and purple are known as "cold" and that warm colours are associated with happiness, pleasure, energy and stimulation while the cold colours are associated with calmness, healing, sadness. These chromatic effects from exposure to variations in colour temperature have theraputic properties and chromotherapy, the use of colour in therapy, has been practiced for millenia [12].

In this demo we describe a customisable wearable device to capture the dominant colour of the wearer's environment. Previous visual lifelogging devices such the SenseCam capture whole images [11], whereas our interest is in storing only the single dominant colour value so the details of one's life can't be reconstructed thus negating privacy concerns. In order to determine the parameters for our colour sensing device we report a simulation using a SenseCam where whole images were post-processed to determine how frequently to sample, and what area of the "image" should be used to define the dominant colour.

This paper is organised as follows: In Section 2 we provide additional background material motivating the relevance of extracting the colours of everyday life, and how this influences peoples' mood. Section 3 supplies details on our wearable device for capturing only dominant colours. Section 4 explains our actual demo, and Section 5 provides conclu-


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sions on what we have learned and reflections on prospective non-invasive low-entropy wearable devices for capturing our environments.

## 2. RELATED WORK

The earliest published work on the impact of colour on our mood is probably that by Wexner who studied people's perceptions of how colour and mood are correlated, but did not study how colour actually affects mood [19]. More recently, researchers have investigated the influence of colour on both mood, and cognitive performance and found that subjects perform better in short-term memory and in cognitive performance when exposed to warmer colours [1]. Kuller *et. al.* studied colours and light in indoor work environments with almost 1,000 people involved in their study but focused on light intensity rather than colours [13]. Earlier work by McCloughan *et. al.* also found correlations between light intensity and mood and also observed a correlation between colour and hostility levels [15]. Hubalek *et. al.* recently reported a study on light levels to which office workers were exposed but was not able to conclude anything on the relationship between exposure to different light colours, and mood or cognitive performance [12]. Given the known strength of visual imagery as a cue to accessing memories [8], in this work we investigate whether colour alone can act as a sufficient prompt to help understand the lighting environments that a person is exposed to, thus being a valuable tool to the ergonomic research community.

Steve Mann has pioneered the effort to make visual lifelogging devices smaller [14] and research is still ongoing in trying to make them even smaller and more ubiquitous. The WayMarkr project of NYU uses a mobile phone affixed to a strap to take pictures automatically [9]. Microsoft Research in Cambridge, U.K., has further advanced the field through the introduction of the SenseCam [11].

As lifelogging has become more prevalent, some people have expressed concern over the fact that many of the mundane details of our lives will be recorded, and there is a feeling that ethical and privacy concerns offer a significant barrier to the uptake of lifelogging devices [4, 16, 5]. Eventually we believe that the benefits of lifelogging [6] will outweigh any potential privacy concerns. However this may take a period of time, thus in this work we detail a novel wearable capture device which stores only the dominant colour rather than a full image.

## 3. CAPTURING THE COLOUR OF ONE'S LIFE

We propose the use of a 25mm mote as a 3-D modular system which can be used for fast and easy prototyping [17] and has over 30 system layers available for integration into a customised building block including a large quantity of sensor layers enabling this system to be used in a multitude of applications e.g. [17] The mote (see Figure 2) is programmed using C, assembly, Contiki or TinyOS and data processing requirements can be met as appropriate through the inclusion of a FPGA based layer [7] in the system stack, along with the capability to store up to 2GB of data in the memory layer. Standard sensors which have been integrated into various implementations of the system include occupancy detectors, PIR based sensors, temperature sensors, accelerometers, gyroscope and compasses, CO2 sensors, water level, pH, dissolved oxygen and phosphate concentrations etc.

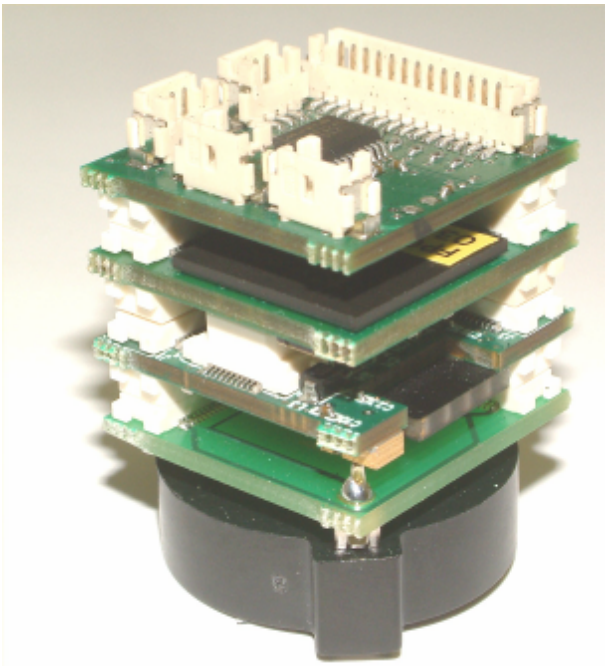

**Figure 2: Our 25mm Modular WSN Prototyping Platform**

### 3.1 Visualising Dominant Colour Across Collections of Images

The visualisation of colours across a number of images was inspired by the work of [18]. In this demo, we extend this idea through parametrising a wheel by colour, time *and* frequency of images. The first stage of the visualisation technique clusters the database of input images according to a user-defined period, $u_{time}$, defined as a number of seconds, hours, days, weeks, etc. As a user tends to turn the colour sensor off at particular times (for example during sleep), some of these time clusters may contain no images, and so are deleted from the visualisation. In order to make a more appealing visualisation, a number of user-defined smoothing iterations are performed. This is simply achieved by averaging neighbouring clusters to $C_i$ within a distance $u_{dist}$ (i.e. $C_i = \Sigma_{-u_{dist}}^{+u_{dist}} C_j$) and re-normalising to the initial size of $C_i$. This process is then reiterated $u_{iter}$ times.

## 4. SYSTEM DEMONSTRATION

### 4.1 Camera Module Hardware Development

The camera that has been chosen for this project is the 13N1 CMOS Camera Module, manufactured by Microjet Technologies, Ltd. [2] shown in Figure 3. This is a low cost, low power camera integrating an OmniVision OV7649 [3] image sensor and lens into a single module. A 20-pin connector provides access to the image sensor. While the image quality of this device is relatively poor (the camera module has a resolution of approximately 0.3 mega pixels) it is sufficient for the required implementation as only the colour levels are of interest.

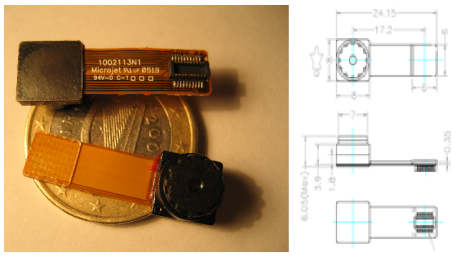

**Figure 3: WSN Camera Interface Board**

The OmniVision OV7649 image sensor provides the functionality of a single-chip VGA (640 x 480) camera and image processor. The sensor provides full-frame, sub-sampled or windowed 8-bit images in a wide range of formats (YUV/YCbCr 4:2:2, RGB 4:2:2 and Raw RGB Data), controlled through OmniVision's Serial Camera Control Bus (SCCB) interface. The camera is controlled via a serial two-wire interface consisting of a clock and data signal called the SCCB bus. The image sensor has a series of registers whose values can be altered by the host processor through the SCCB to control brightness, contrast, resolution, sampling rate and other settings.

A camera WSN interface module was developed so as to interface with the camera and to allow for image acquisition testing and algorithm development. It consists of the camera connector, crystal oscillator, power supply and additional connectors to allow data to be read to and from the camera module through a National Instruments Data Acquisition Board. The system was designed to be compatible with ourl 25mm wireless sensor network prototyping platform and its associated family of sensor and ISM band radio layers, as well as its FPGA compatible layers [7] to enable complex algorithms to be carried out as appropriate in the system. The completed CMOS camera WSN interface board can be seen in Figure 4

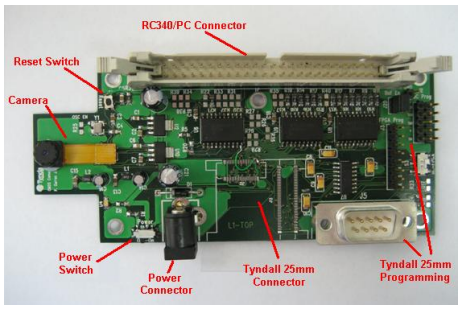


**Figure 4: Microjet 13N1 CMOS Camera Module Image and Dimensions (mm)**

## 4.2 Simulated System Output

To simulate the output of our demo system, a large group of users, we gathered SenseCam data from 20 individuals over a period of 4 years. All participants had a variety of experiences and wore the SenseCam for short (min = 1 days) or extended periods of time (max = 869 days), with a median wear period of 10 days. In total 3,441,225 images were captured, were then segmented into 40,485 events [10], from which the dominant HSV was extracted.

Figure 5 shows the dominant colours selected from a group of 5 retired people who wore the SenseCam. Many dark colours occur as some in this group of people were homebound, however of those who did go outside (bright colours at the top of the chart) tended to do so during the afternoons, possibly due to not having work commitments. The x-axis shows time during the day.

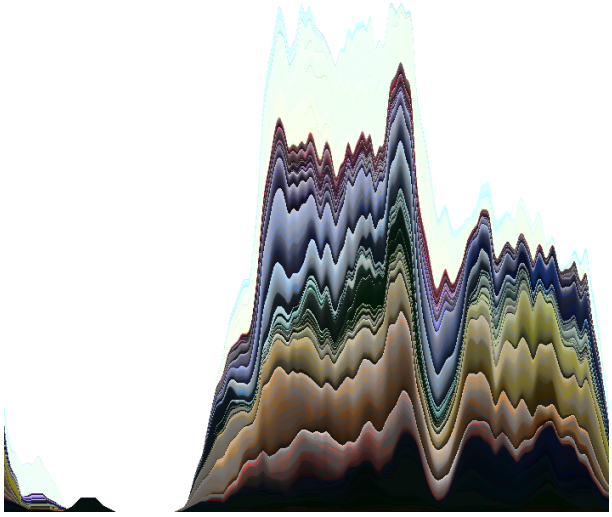

**Figure 5: Typical colours experienced in an average week day by retired group of 5x people - note lighter colours earlier in day for morning walk**

Figure 6 shows the dominant colours from a group of 7 researchers for their typical weekdays. The dominant colours are shades of yellow/pink (indicating skin tone of their own arms and hands while working at keyboards) and also blue/purple (the tone of office colour). These generally occur between 10:00 and 19:00 hours, indicating the working patterns of these users, with office and work tones particularly strong between 13:00 and 17:00.

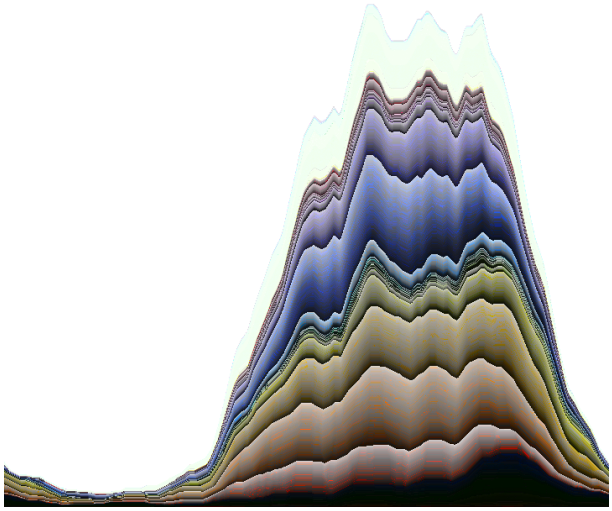

**Figure 6: Typical colours experienced in an average week day by lifelogger group of 7x people - note many blue/purple office environment colours**

Finally Figure 7 contrasts with Figure 6 in that it shows the colours from our group of 7 researchers at weekends. Images are generally captured at later times, and also there are many more bright colours to indicate this group of people spend more time outdoors at the weekend.

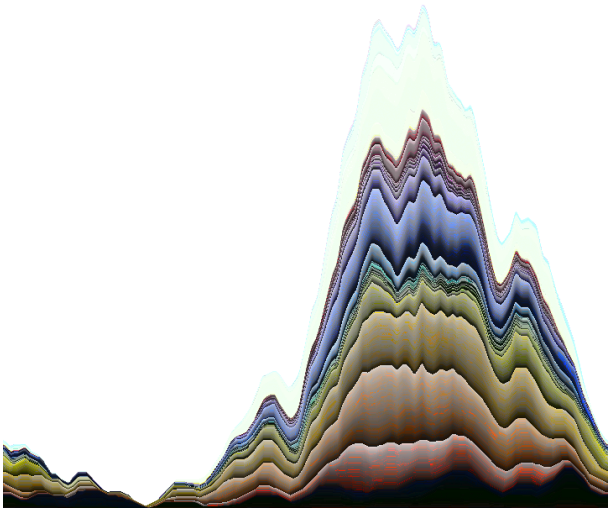

**Figure 7: Typical colours experienced in an average weekend by lifelogger group of 7x people - note bright colours around 15:00 hours showing more time spent outdoors, followed by lunch at approximately 18:00, before going outside again at 20:00**

## 5. CONCLUSIONS

In this demo we introduce a new wearable lifelogging device to capture colour blobs only. An advantage in doing this is that privacy concerns are addressed, and we show that through the capture of a dominant colour alone, inferences can be made on the environment and lifestyle. As shown in the literature review, many studies correlate the dominant colours of environments with the mood of people in those environments. We believe that our capture device may well be a valuable ergonomic tool for exploring this further.

As part of the demonstration of this (if accepted) at ACM Multimedia, we will capture the colour of the presenter's life in the days leading up to the presentation, travel to Firenze, time at hotel, time at conference, time at conference dinner, etc., so the audience can relate firsthand to what is demonstrated.

## Acknowledgments

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