**Developing an affect enhanced "Turrellian" RGB LED lamp designed to improve mood: towards multimodal affect-sensitive computing and devices.**

**EXECUTIVE SUMMARY**

**INTRODUCTION**

***Context***

No aspect of mankind’s mental life has more pertinence to the quality and meaning of our very existence than emotions. Quite simply, emotions make our life worth living and sometimes worth ending. With the advent of computers, it became inevitable that systems and devices would be increasingly used to recognise, process, simulate and interpret human affects.

Coupled with the exponential increase in transistors on silicon integrated circuits (microchips), Moore’s Law has promulgated exuberant innovation in computing technology. Resulting in computing technologies that will increasingly embed themselves into the fabric of our everyday living spaces, project the human user into the foreground. Indeed, these user-centric and intelligent computer systems will seamlessly serve the needs of the user with software operating automatically in the background.

These advances in computing power, wearable computer devices and interaction modalities promises a new dawn for computer systems and applications. Indeed, since Rosalind Picard’s, notable paper and book on affective computing in 1995 – much research has been established towards developing affect-sensitive computers, systems, interfaces and robots.

Additionally, in more recent times, prominent researchers Pantic et al. have encouraged the development of multimodal computing (or HCI2) – specifically computing which can understand and respond to natural and autonomic modes of human communication such as emotion automatically. These devices or interfaces should transcend the traditional keyboard and mouse, succinctly understanding and adapting to human behaviour and signals.

In this vision of the future, often referred to as “ambient intelligence” humans will be surrounded by intelligent yet invisible multimodal computer devices that can anticipate all our daily needs. For instance, cars will automatically pull over if a driver becomes drowsy, our favourite music will be played by speakers when we come home weary after a long day at work and smart watches may prompt us with notifications to remind us to meditate when we are feeling stressed or agitated.

There are significant advantages to these increasingly empathetic and multimodal computers, interfaces and devices. Evidence from multimodal human computer interaction (MHCI) research finds that they are more human-like, usable, efficient and effective. Not only this, but these multimodal affect-sensitive computers and devices certainly have the capacity to significantly improve users’ day-to-day moods, emotions, routines and overall quality of life.

Spectrums of coloured lighting diffused by an internet of things (IoT) lamp has been chosen as the most appropriate natural medium to explore enhancing the mood of users. This is because different spectrums of lighting have been proven to have a non-invasive range of health and emotional benefits from improving concentration and sleep to even alleviating depression and migraines.

Additionally, there are an increasingly popular variety of IoT lighting devices designed to treat specific health disorders or on-command calibrate specific suitable environmental ambiences for their users. Therefore, there is undoubtedly value in adding more to this IoT lighting market by providing a device which acts automatically enriches users’ affective state, mood and experience.

Furthermore consumers have readily purchased

Due to the sensorial works of artist James Turrell, the growing demand for ‘health’ orientated IoT light devices, significant findings from ambience research, neuroscience and psychology.

Disparate fields of study / Light as a medium for health and mood

Lighting, ambience research, artist James Turrell has conclusively found multiple health and emotional benefits coherent with

There are significant advantages to multimodal affect-sensitive computer devices and systems.

Devices capable of understanding users intimately – achieve mood improvement, be easier to use etc.

***James Turrell***

As the device-namesake James Turrell’s artwork has been a dominant influence in this research.

Turrell’s work explores the immateriality of light – building on the sensorial and emotional experience of space and colour. His oeuvre, phenomenological lightscapes feature technically advanced LEDs, which are configured by computer programming. These innovative and photographic techniques enable light to have a physical presence and fill the space – immersing all onlookers.

These expositions and spaces engage viewers – capturing the limits and wonders of human perception prompting an incredibly transcendental and emotional experience. As Turrell aptly notes, “my material is light and it is responsive to your seeing”.

In this sense, Turrells work hones visitors’ senses by removing perception and enabling colour to fully inhabit and immerse the space. Throughout history and regardless of culture or ideology, humans have attributed significance – both literal and metaphorical – to light and that storied relationship is central to Turrell’s practice.

In particular, his expositions focusing on the Ganzfeld effect as pictured above offer total loss of depth perception enabling colour to fully inhabit and immerse the space [6]. This experience has prompted a transcendental and often relaxing experience for visitors of his work and spaces [2, 6].

**Device significance?**

***Turrellian Lamp***

Multimodal human computer interaction (MHCI) researchers have processed different natural human modalities to extract user’s emotions with prominent techniques including facial expressions, vocal intonations, textual analysis and physiological reactions. In particular, facial expression, vocal intonations and physiological reactions enable MHCI researchers to achieve automatic processing of users emotion.

Disparate studies of differing modalities have resulted in ultimately a marked contrast in the modalities and methodologies employed by MHCI researchers designing affect-enhanced computer systems. In fact, it is a misjudgement to assume that all human interactive modalities (sight, sound and touch) and non-verbal interactive signals have been studied equally.

Rather facial expressions utilising both machine learning and AI has become dominant and most central to providing automatic affective feedback recognition for computer systems. In contrast, body gestures or physiological signals, textual sentiment analysis and auditory analysis have to a greater extent represented a more secondary role in multimodal computing technologies affect-sensing research.

However, this research supports the contention that a broad fusion of approaches is most desirable to creating affect

***Collaborative design ethos***

***Overview of research paper***

Product release cycle

***Research output***

**Part 1 – LITERATURE REVIEW**

***Chapter – Affective computing***

***Chapter – Light, emotion and IoT light devices***

***Chapter – Embodied, scaffolded emotion and multimodal affect-sensitive computer architectures***

**Part 2 – PROTOTYPING, TESTING AND DEVELOPMENT**

***Chapter – Prototyping and hardware development***

***Chapter – Physiological affect-sensors***

***Chapter – Software and web application integration***

**Chapter Introduction**

In this section I exhibit initial sketches, prototyping and development of the project. The focus of this project was on aesthetic outcomes, interaction and early delivery of the lamp. Additionally, the lack of commercial devices utilising affect-sensitive platforms or LED coloured lighting to improve mood meant that a clear empirical and user-centric approach to research seemed most appropriate. Throughout alpha and beta development of the Turrellian RGB LED lamp – I incorporated an agile development cycle resulting in the development of several projects and incorporation of user-feedback for continual improvement whenever possible. Only here due to the consequences of the Coronavirus pandemic and pioneering nature of the project– I proceeded informally and opportunistically, utilising friends, family and colleagues whenever possible.

As discussed in the previous section, prototyping was carried out in MAX/MSP - a high-level music development environment, which allows fast development of musical and interaction ideas. To work in this way I first had to develop a library which allowed simulation and control of Matsuoka’s Neural Oscillator(MNO) nodes in MAX/MSP.

**Part 3 – RELEASE CANDIDATE AND UX TESTING**

**Part 4 – OUTCOMES AND FUTURE WORK**