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DESIGN AND DEVELOPMENT OF DYNAMIC LIGHTING SYSTEM USING AMBIENT LIGHTING TECHNOLOGY

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ABSTRACT

Ambient light is a general light that is previously present in the scene, before any supplementary light is added, illuminating a particular area and thus providing a contented intensity of brightness without glare. Ambient backlighting for TV displays is a promising technology providing solution to visual fatigue caused due to watching TV under dark environment- backed up by scientific experiments. This paper will review ambient lighting in general, various indoor lighting available, implementation of ambient backlighting for TV displays, different configurations in hardware design according to the user, applications and possible advancement in this technology.

Keywords: *Ambient lighting, Hyperion, Kodi, LED strip and Raspberry Pi.*

1. INTRODUCTION

An eye strain is likely to be experienced while viewing TV under low luminance. The trend of using present day display systems has led to an increase in cases of eye disorders. TV screens utilize fluorescent tubes to illuminate the screen. Fluorescent tubes have an issue in creating deep blacks, which play an important role in helping the viewer perceive other colors better. It is essential to produce pure black levels to enhance the viewing experience. Color saturation is affected by the light leakage in displays, which in turn leads to failure in creation of distinct images. The consequence of this is the continual attempts by the eyes to focus and refocus, causing progressive damage. The constant readjustment of the eyes to adapt to all the changes causes the pupil to open wider, effectuating dry eyes. Further, the TVs use PWM (Pulse Width Modulation) to vary the brightness level. PWM causes distracting visual effects. Perpetuated exposure to short-wave visible light (violet/blue end of the visible light spectrum) of display can cause detrimentation of the retina of the eye.

The problems stated above demands for a system that can overcome the tainting effects of watching TV in the dark. There is a need for technology that is capable of providing deeper black levels with better color saturation and creates a perception of distinct images. Such a system can reduce the adverse effects on eyes and in turn enhance the viewer experience.

The term ambient light refers to a system that is capable of providing uniform illumination. This system may be the antecedent sunlight or artificially created ones such as the room lights. Ambient lighting technology is blending the RGB colors by varying the potentials of digitally controlled LED lights. The various configurations are achieved by regulating the LEDs using a micro computer. The system is ensured to have no visible sources of light emission[1].

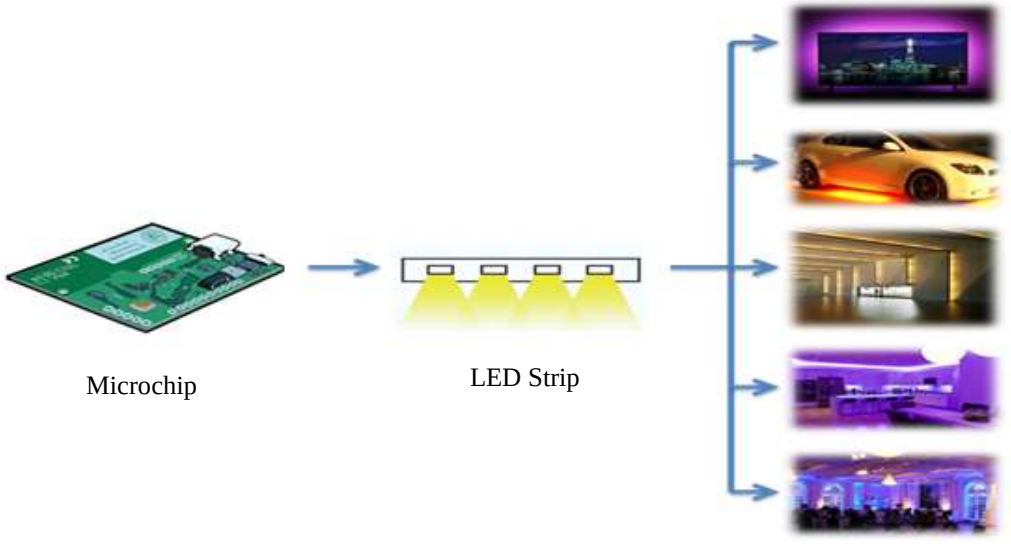

Figure 1: General Ambient Lighting Implementation

2. LITERATURE SURVEY

In this section, we present the survey and analysis of few similar earlier research paper contributions from national and international journals in the same domain.

From a study conducted by a group of professors from Graduate School of Advanced Integration Science, Chiba University, Japan it was evident that a better realistic impression was experienced with an endurance of fatiguing sensation in a dark room. The experiment involved subjection of participants to two different kinds of illumination- the first, a white board reflecting the light emitted from RGB LED strip arrangement setup at the rear-end of the TV and the other was an illumination from the ceiling using fluorescent lamp. All participants were kept unaware of the basis of evaluation. The two factors considered were “sensation dynamism” and “comfort”.

This reference outlines the consequences of viewing TV in a low light room for prolonged hours. The study was conducted by researchers from the Lighting Research Center (LRC), a division of Rensselaer Polytechnic Institute. The research was administered on volunteers against a flat screen TV and it was focused only on Eye Strain which arose from the illumination of the TV screens and the dark environment around it. Two groups of volunteers were enthralled to watch the TV in both of the cases, the first one with TV in dark environment and the other one with an illuminated wall surrounding the TV. The outcome of the experimentation showed that there was comparatively less eyestrain, visual fatigue and discomfort when the TV was watched against a luminous wall. The main effects were due to improper focusing, sleepiness, and the

duration of intervals between the visual cues test and electrophysiological neural responses. The participants' review post study was that the effect of watching TV in dark room was moderate and it did not cause any actual damage to eyes. The participants complained of eye fatigue[2].

The School of ESE, Southeast University, China, studied the effects of Ambient light on eye strain while watching television. The experiment conducted involved three cases. The first was full modulated LED light source of 120Hz frequency. The second, an ordinary FL source and the third was a dark environment. Fatigue was measured, considering 12 symptoms and ophthalmological parameters like CFF, NPA, etc. both prior to and followed by watching TV. Though both the ratings were more for fatigue after watching television under all three cases, the ratings were subjectively higher for watching television in dark room [3].

Sl no	Types	Description	Applications
1)	General Lighting a) Direct	Direct Lighting induces even lighting over the horizontal plane.	Museums, exhibitions, pedestrian traffic areas.
	b) Indirect	Indirect lighting utilizes a secondary reflector such as wall, ceiling, etc. to delineate the expanse.	Uplights, working areas.
	c) Direct and Indirect	Direct and Indirect-Hybrid of Direct and Indirect	Pendant downlights
2)	Accentuation	Accentuation light emphasizes on discrete entities highlighting the prominent objects from the rest.	Spotlights, directional downlights, tasklights, etc.
3)	Washlighting	Washlighting highlights larger area by distributing the light over wide beam.	Flood lights, sales and presentation areas, etc.
4)	Wallwashing	Horizontal lighting used to illuminate the vertical planes.	Subways, elevated flyover, panoramic walls, etc.
5)	Projection	Patterns are projected using structured lenses, filters and stencils.	Restaurant, cafés, wine bars, hotels, etc.
6)	Orientation lighting	Arrangement of lights at specific points to improve perception.	Architectural lines, emergency exit routes, etc.

Figure 2: The Brief Description of types of Lighting

The above table generalizes the various ways light can be projected to highlight the vital areas. Different effects can be achieved just by altering the arrangement of the light source. The arrangements are application specific; certain applications demand for illumination of entire area whereas others need just highlighting of specific objects. The same can be achieved through implementation of the appropriate organization[4].

3. SYSTEM DESCRIPTION

3.1 HARDWARE REQUIREMENTS

The hardware components are inter-connected as depicted in the block diagram. In the proposed diagram entertainment system can be a set-top box, laptop or any other HDMI source. The HDMI source is split amongst television and Raspberry Pi using a HDMI splitter. Since direct video conversion is unrealizable from HDMI to Raspberry Pi, HDMI to AV converter and USB video grabber is used. The LED strip is connected to the Raspberry Pi and the external power supply which are mounted on the anterior of the television screen.

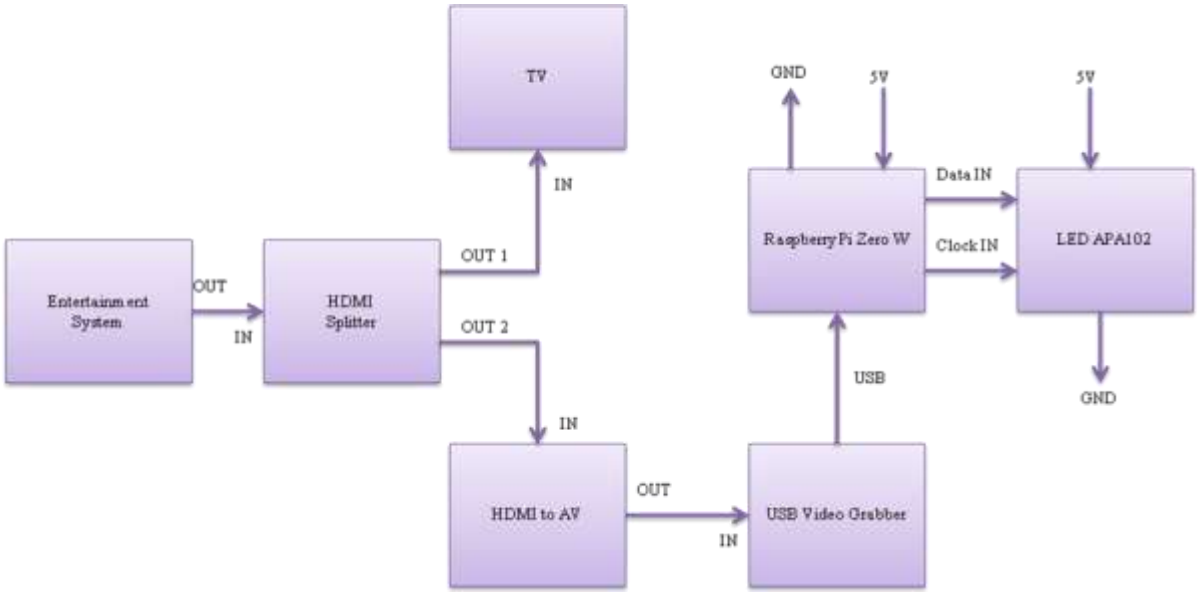

Figure 3: Hardware Implementation Using USB Video Grabber

3.2 SOFTWARE REQUIREMENTS

This project makes use of software called Hyperion, which is an open source Ambilight implementation that runs on many platforms. The main features of Hyperion includes low CPU load, JavaScript Object Notation (JSON) interface, remote application (Android app), Boblight server interface, Black border detection, generic software architecture and a scriptable effect engine which can support latest devices and new algorithms easily. Hyperion allows the user to customize the parameters of the LEDs through HyperCon. HyperCon is a tool that generates a Hyperion configuration file and is capable of remembering the settings of the previous run.

Hyperion works on various hardware platforms such as Raspberry Pi, 32/64bit (no BSD/Windows), iMX6, Wetek and operating systems such as Raspbian, OpenELEC, OSMC, LibreELEC, RetroPie, RasPlex, PlexMediaPlayer, Embedded Linux and Mac OSX. It is also compatible with commercially available products such as Philips Hue and AtmoOrb.

4. IMPLEMENTATION AND RESULTS

Using NOOBS, Raspbian OS and Hyperion is installed on Raspberry Pi Zero W. It has an inbuilt Wi-Fi which after configuration connects automatically to HyperCon through a specific IP and port address[5]. The clock and data pins of addressable APA102 LED strip mounted behind the TV screen connected to Raspberry pi is controlled using Hyperion and HyperCon through a specific port and IP address. Several effects and patterns based on the user can be produced manually using Hyperion application on various platforms such as android

and windows. Further the HDMI video source can be automatically interfaced with the LED strip using USB video grabber or Kodi.

USB video grabber, a hardware component can be replaced by software called Kodi. Kodi is an open source media player containing add-ons like YouTube and Netflix, works on several platforms such as iOS, Windows, Mac OS X and Linux operating systems. Hyperion add-on for Kodi allows the user to access the LED's without the help of HDMI to AV converter, splitter and the USB video grabber using IP address of the Raspberry Pi.

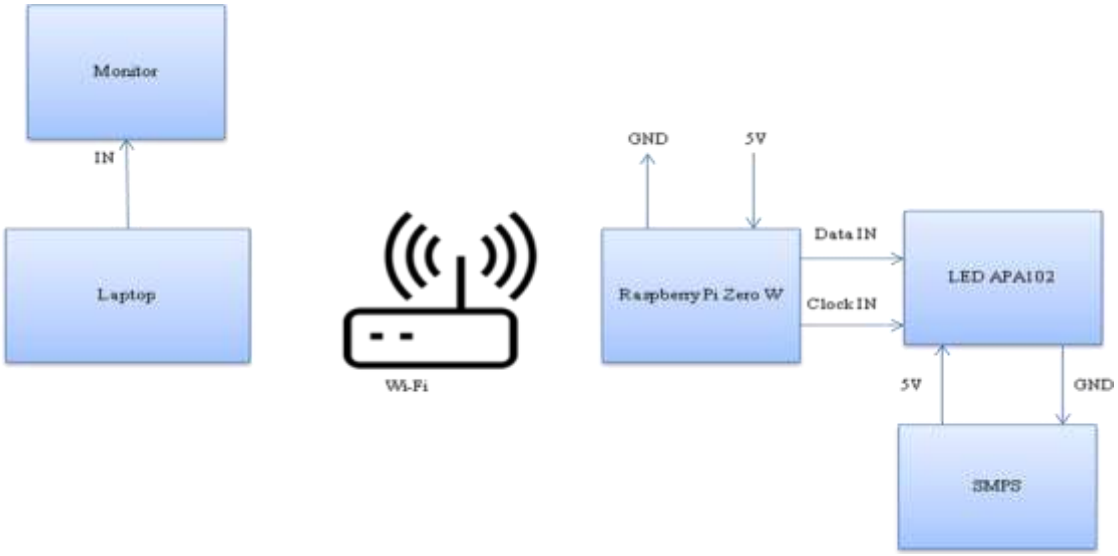

Figure 4: Simplified Block Diagram for use with Kodi

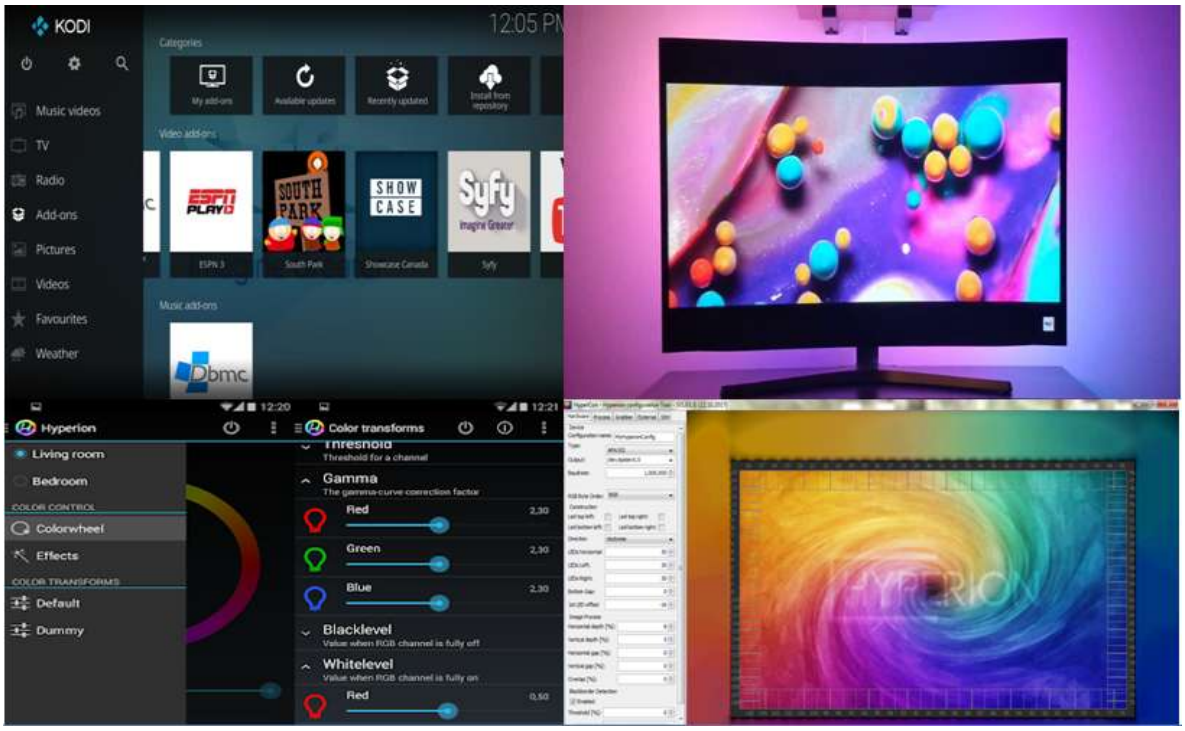

Figure 5: KODI Media Player, Ambient light implementation, HyperCon interface, Android Application for Hyperion. (Clockwise From Top)

5. APPLICATIONS

Ambient light sensor unlike phototransistors and photocells adapt to large variation in light intensities, works by subtracting or adding a persistent amount of backlight. This technique works exceptionally well in preventing the robots from going blind when suddenly exposed to bright light or dark corners[6]. Its spectral response is as accurate as a human eye capturing prodigious range of illuminance and luminous emittance operating at wide range of temperatures. It can be used in a wide range of light sensing applications. These sensors find applications in various domains such as robotics, weather stations, automobiles, interior design, photography, etc[7].

Ambient light technology is combined with Infrared sensors offering excellent background light nullifying capabilities- combining ambient light photo detectors and an IR emitter with proximity for long-distance detection, eliminating crosstalk, vehicle occupancy detection in parking lots, collision avoidance in robots, lighting control in homes, offices, schools, corridors and other public buildings, etc[8],[9].

This technology can be implemented using a microcontroller and LED strip which can be used as a bias lighting to television screens- enhancing the viewing experience and prevents the user from various problems as discussed in chapter 2, used in interior designs of cars, homes and auditoriums.

6. CONCLUSION AND FUTURE WORK

This paper presents the design of a dynamic lighting system using ambient lighting technology using one of the fastest LED strip- APA102 and most economical computer- Raspberry Pi Zero W. The open source software's- Hyperion and Kodi used will allow the user to customize the code as per the requirement. Based on the type of HDMI source the user can follow one of the two hardware configurations as provided in sections 3 and 4.

Advance video grabber software can be developed to enable the user to connect computer running on any operating system to Hyperion installed on Raspberry Pi without any additional media player such as Kodi. Further development of an IC which can possibly integrate all necessary components required to interface HDMI source to LEDs enabling the setup to function on any video source like Set-top box and fire TV stick.

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