

State-of-The-Art Holographic Traffic Control System for Future Traffic Environment

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Abstract—These days there is tremendous demand for the integration of technology into vehicles. Due to advance automotive engineering, there are several potential distracters added into the driving situation. Traffic control devices (TCS) play a major role of communication between the driving environment and drivers. But there are many confounding factors such as delays, accidents, improper functioning of traffic lights, traffic volume etc. may mislead the drivers. Holographic style traffic displays are the latest technological developments which can be used as a replacement of current traffic light system. The objective of this paper is to explore the usage of holographic technology to replace the current traffic light system to ensure driver safety. This paper summarizes the limitations of current traffic system and draws the attention to implement holographic style traffic signals. This ensures improved safety, guidance, control and navigation compared to the traffic light systems.

Index Terms— Traffic control devices, Holographic traffic display, Traffic light systems.

I. INTRODUCTION

Traffic control systems principal objective is to manage movement of people and goods efficiently and safely. Traffic control signals can make an orderly system to provide confidence for the drivers and also helps to control the vehicles that are on main and secondary lanes. Traffic control is one of the major technical aspects in controlling traffic flow and improving congestion. The present traffic signalling system is a kind of self-adaptive control system which adjusts the signal timing parameters in real time to control the traffic flow at the interaction. Nearly every year 1.35 million people die due to traffic crashes. These mainly occur among those who are vulnerable riders which are motorcycles, pedestrians and many others. 93% of these fatalities in the world takes place in low- and middle-income countries [1]. Road traffic injuries are major cause for children and young adults. Factors that lead to road crashes and deaths include: road infrastructure, unworthy vehicles, user of vehicle behaviour, inadequate care of roads, post-crash [2]. A railroad should be designed in such a way that it should be safe and efficient if it can accommodate the requirements of passengers at low cost [3]. Safety, one of

the important aspects is decrease the accidents, is another reason for traffic problem. These all will never go together. The current traffic signal system can be made much convenient and better for public if these can be replaced by using holograms to create a wall of light for not only projecting signals: The red, green and yellow lights but also for displaying advertisement, countdown and to reduce accidents to maintain efficiency and safety. The advantage to pedestrian safety would be great along with no missing of signals due to conditional reasons.

Holographic systems are the third pillar to virtual reality / augmented reality (VR /AR).These are just like an aquarium in a living room where along with peers can be able to experience another world without any additional head-on or glasses required. This requires ability to represent the real or digital (objects, people, etc.) with high 3D fidelity; high computational power and high pixel densities are required [4]. Hololens are one of the helping parameter to determine the hologram technology .They can be used with artificial intelligence (AI), VR/AR to create a new advancement in technology. For example, consider Microsoft hologram with Azure AI technology to simply our hindrances and to be comfortable [5].A hologram consists of phase and amplitude which are required to reconstruct a signal. Since, hologram is a 3d image which is quite different from 2d various techniques can be performed, but the common similarity between these two is both must display the image to human visual system. Hence, some additional techniques must be added to the 2d techniques in order to make a 3D image. A hologram video can be captured from an object an optical system using Charge Coupled Device or by calculation of computer .The information that is captured does contains noise. It can encode with standard techniques such as Huffman, Shannon and many others. Digital hologram is from spatial domain to frequency domain. Lossless compression of does contain the information of data as it is without any change in actual image from original image. It has various techniques such as run length coding, Huffman coding, Shannon coding, Lempel -Zip coding, loss techniques does include JPEG, JPEG 2000, segmentation, scan method, normalization. These techniques can make encoding and transform to a 3D image [6].

II. LITERATURE REVIEW

The present traffic light system can be represented using a simple block diagram shown in figure 1.Power supply is given to the system for the lights to work. For a simple circuit AC supply 230V 50 Hz is given to transformer and it is converted to DC of 12v.A switching circuit is included for the power to supply only to that circuit. Timing circuit is used for high speed of operation and for specific time frame of light. Routing is used to give particular output to particular input. The output is LED which is used to display. As technology grew, different traffic based circuits and different methods had adopted traffic signals in different ways. Techniques of traffic control are magnetic are buried inside the road which are known as loop detectors, sensors which are infrared along the sides of road that provides information of traffic at limited content in addition with traffic counting and surveillance. In road traffic, conjunction of lane with left turns that has no opposing traffic with intersection of traffic lights results in intervals which are longer and non-green at the intersection, leads to delay and efficiency is reduced along with mobility. Problems can also occur due to control circuit and non functioning of traffic signals.

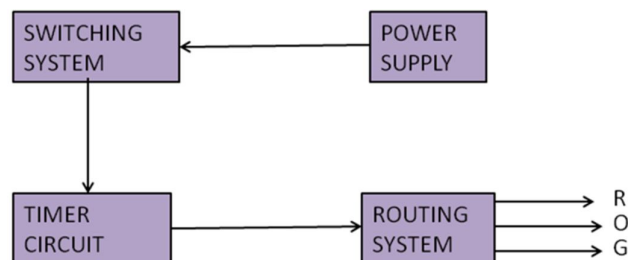


Figure 1.Simple Traffic Block Diagram

Traffic signal controllers are electronic devices which are used to control sequence of lights with time frame. These controllers are combined together to monitor traffic signals which are huge in number. Travelling from one place to another can be difficult at certain circumstances due to traffic congestion and delays. Many times the traditional way of traffic lights is overshadowed by huge electronic advertising signs and focus is lost as lights are less visible. Dennis Gabor (1947) developed the theory of hologram in order to enhance the electron microscopy resolution. He named the term hologram as halos mean whole and gram as message. Further at that time light source exist which were not truly coherent. It was overcome by N.BASSOV and A. Prokhorov and

Charles with invention of laser making ideal for holograms. Juris Upatnieks and Emmett Leith (1962) recognized that holography could be in digital medium. They made the first laser transmission of toy train and bird in 3D. It required laser for transmission but produced with clarity and reality. In the same year, Dr. Yuri N. Denisyuk combined holography with photography of color. This approach led to hologram of white reflection which can be viewed in light of ordinary bulb. Dr. Stephen and A. Benton (1968) invented holography of white light transmission. The rainbow spectrum of white light transmission attracted more number of people who adapted this work to their requirement and made holography popular. Lloyd Cross (1972) incorporated white-light transmission with traditional cinematography to make motion of 3-dimensional images. Victor Komar et al., made a prototype for a holographic projection movie. Holographic camera which is of pulsed is used to record the images and it was projected onto a holographic screen that focused the image of multi dimensional projected to public [7]. Akshay Ratan et.al, paper an introduction about holograms and gave a glimpse about basics of holograms which are interface, diffraction grating, photographic plate, interface pattern [8, 9]. Interface is the method where two waves superimpose on each other to form a wave of greater or lesser amplitude. Diffraction grating is the light pattern which is recorded. Photographic plate is the one that records the intensities of light and the phase information is contained by interface pattern. The paper also mentions recording and reproducing light of hologram. Applications of hologram include Holographic Interferometers, Data Storage, Holographic Sensors, Security and its importance with holography. Nakshatra Sharma et.al. talks about the hologram technology and its types[10]. There are two types of amplitude and phase modulation holograms, where the light amplitude which is diffracted is proportional to the intensity of the light which is recorded and phase holograms are those which are formed by variation in the thickness or in variation of the refractive index of material which is proportional to the intensity of interference pattern, Transmission and reflection holograms are those where the one, the object and other, the reference beams are incident on medium which gets recorded from the same side. This paper paid attention to working of hologram and its applications such as Holographic Microscopy, Art and many others. Khushboo Kumari et.al. discussed about the hologram and its types [11]. The word hologram is the Greek word "hole" and grammas, meaning "message". Many developments were made but cannot be fulfilled for coherent light. This difficulty was overcome with the innovation of lasers, which was ideal for making holograms due to its pure, intense light. Li Weiying proposed hologram projection based on computer graphics [12]. The author represented the object in coordinated system with mathematical model. This mathematical model representation of object in coordinate system transforms into a hologram stripe which is based on diffraction and interference. This is calculated block. The modulator modulates the incident light and hologram stripes and converts into visible three-dimensional images from stripes. This is reproduction process. Robert J. Perlmutter et.al. made efforts to generate holograms from diagnostic scans [13, 14]. The author used several approaches such as Burch, Brown and Lohmann and computed the time needed to generate the hologram using suitable transformation techniques. They also calculated the amount of storage space required for the values, and the time taken for reproduction of holograms. They had used Fresnel algorithm of diffraction pattern to production of holograms. Sandra et.al. presented the hologram as a teacher [15, 16]. The papers pay attention to the hologram in education system and how students feel about the presence of hologram in form of a teacher. The paper dealt with research on education by dividing the students into groups and studying the parameters between teacher as a hologram and direct presence of teacher. They developed an instrument and variables were recorded such as curiosity, concentration, persistence etc. Lepotier et.al. worked on the reconstruction of hologram [17, 18] by using spatial light modulators. But the reconstructed image was not as enough of high resolution to display image of wide range. They proposed Direct Binary Search Algorithm (DBSA) in order to convert the grey scale hologram into binary hologram with a good accuracy. The principle of DBSA is that to binary image is compared with reference image and each time mean square error should be computed and changes were made by not computing mean square error alone with reconstructed image distance can be easily modified. Abdullah et.al. suggested holograms with hand gesture to enhance the education system which is smart holography for teaching [19, 20]. The authors used pyramid reflection hologram to reproduce the image. Hand gesture was also used to control the actions from conversion of movements of hands to commands. Section 1 discusses about brief introduction about hologram and its resemblance with camera. Section 2 discuss about its components with block diagrams. Section 3 discuss about creation of hologram. Section 4 discuss about reproduction of hologram and introduces to the topic of hologram traffic concept with predefined knowledge of working of holograms.

III. PROPOSED WORK

A. Introduction about Hologram

For traffic control to be safe and efficient use with reduction of accidents, hologram concept is introduced. This can be proposed with hologram traffic display as illustrated in figure 2. It is a rectangular wall of horizontal and vertical wall along the road with 3D image projection. This virtual wall concept can be done by using holographic projector. Patterns of lights which are recorded are Holography. When these patterns are represented in 3D image then it forms a hologram. Hologram working is just like camera where, when a picture is taken with the help of camera, some of the basic steps follow such as 1. Opening of shutter. 2. Light hits the film through the lens which is the photographic emulsion.

3. Light reacts with silver Halide which leads to capture its amplitude, or intensity.
4. The shutter closes.

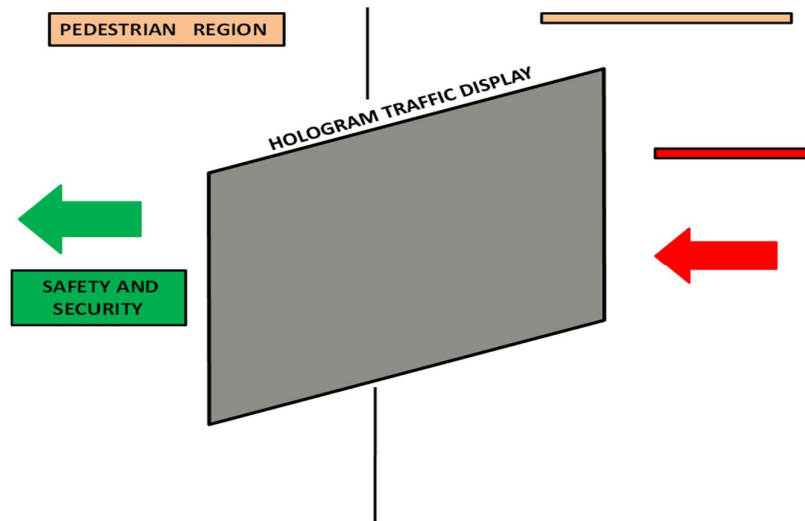


Figure 2. Hologram Traffic Display Virtual Wall

Here, output of the camera is the picture which has recorded the reflected light of intensity, regardless of any changes made. Similar to camera which records photos, holograms are recorded version of reflected light. Steps are as same as photographic changes and this working can be used for traffic monitoring just like traffic signals. Figure 3 shows the creation of holograms.

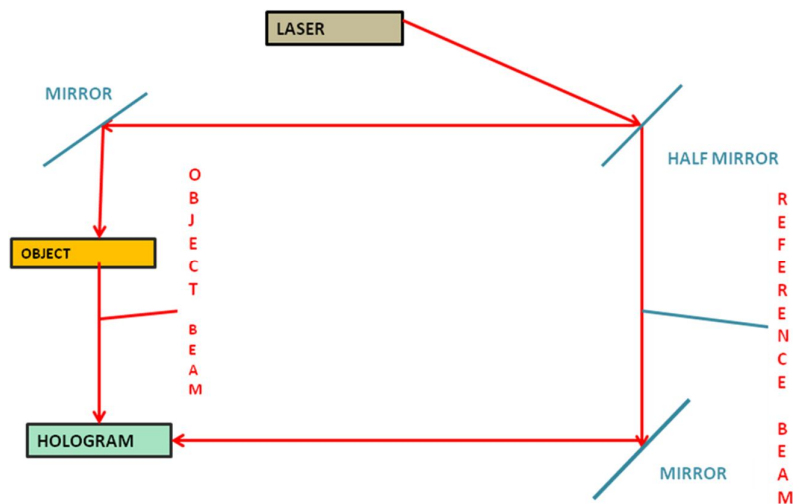


Figure3. Creation of Hologram

Creation of hologram is based on working of hologram that can be used to create a barrier of interface for vehicles. This hologram is of two step process.

1. Creation of hologram.
2. Reproduction of hologram.

B. Components of Hologram

These components of hologram are used in working of hologram and are required as a subset to in traffic hologram signals. Knowing these components can be useful in traffic system if at all any replacement is required. From figure 3, we have:

- **Laser:** Helium-neon (HeNe) lasers, are commonly used which are in the category of red lasers. Experiments also depend on diodes which cannot make good image unlike lasers which are less coherent and less stable. Sutter can also used to control laser with implementation of different colors.
- **Lenses:** Although hologram requires lenses, these are named as "lens less photography". Lenses are used to spread the beam of the light.
- **Beam splitter:** Beam splitter makes the light to split into two different beams.
- **Mirrors:** These help the laser beam to direct to desired location. Mirrors must be clean along with beam splitter and lenses. If dirt and smudges retard on mirrors, they may degrade the quality of the final image.
- **Holographic film:** High resolution light can be recorded. It's is just like photographic film layer of light-sensitive compounds. This film must be able to record very minute changes.

C. Creation of Hologram

The working of Hologram can be illustrated as splitting into two different paths of the laser beam. When the laser hits half mirror it diverges into two different paths. One of the paths hits the mirror and passes through the objected falls on the photographic plate. This path is known as object beam. Another path hits the mirror and directly falls on the photographic path which is known as reference beam. These half-mirrors must be silver polished so that it redirects the beams. Holograms are created when these two beams meet up each other on photographic plate. This hologram will record images, videos which can be used as 3D in hologram display for traffic signals.

D. Reproduction of hologram

In photograph it records the incoming light. This can be seen as light and dark in negative of image in camera. But this is not in holographic plate where prediction of original scene is impossible. Pattern of swirls and lines can be observed. It requires right illumination to turn the film into an image. White light reflects the surface in reflection hologram.

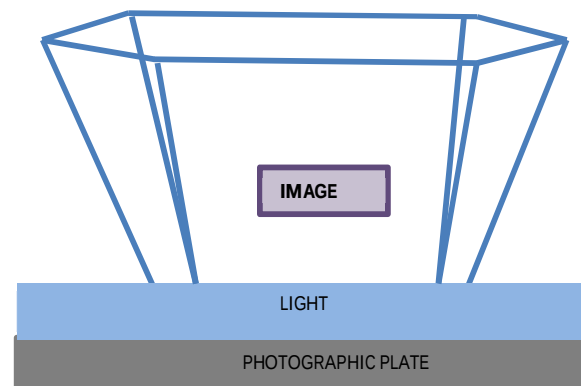


Figure 4. Reproduction of Hologram

Eyes and brain interpret this light as a three-dimensional object representation. The second step is to reproduces hologram: the hologram is a record the original image and it's conjugate. The reproduced image must be three-dimensional which must look like real. Each part of the hologram records the object light and it has ability to produce every part that looks like the original image. This reproduction can reproduce the recorded image or videos like a virtual wall on the roads and can act as a signal. Figure 4 shows the reproduction of hologram. Once working of holograms and its reproduction is understood then it can be implemented in traffic signals.

These recordings with the help of projection plate of projectors can be installed on either side of road near traffic signals or connected to traffic signals horizontally which can be used to improve traffic efficiency. Figure 5 shows the block diagram of holographic traffic control system.

Basic block diagram of the traffic control using holograms consists of microcontroller, control circuit, power supply, display, and hologram. Microcontroller is used where the input is hologram. These inputs can be images, videos of hologram and the recordings of it are stored in memory. Power supply is given to microcontroller in order to work. Control circuit is used to maintain the time frame of each light like how much time the lights must be flashed, what color must be flashed and program must be written in such a way that alternate road lights must be displaying.

This can be better explained by figure 6. In figure 6, hologram lights of green and red are projected at junctions of road is considered. Consider as case 1, where alternate signals are red and other alternate signals are green. After a time limit of signals these signals again change into case 2 case where the lights before displayed red now display green and vice versa. This cannot be applied at junctions but also at other cases as well.

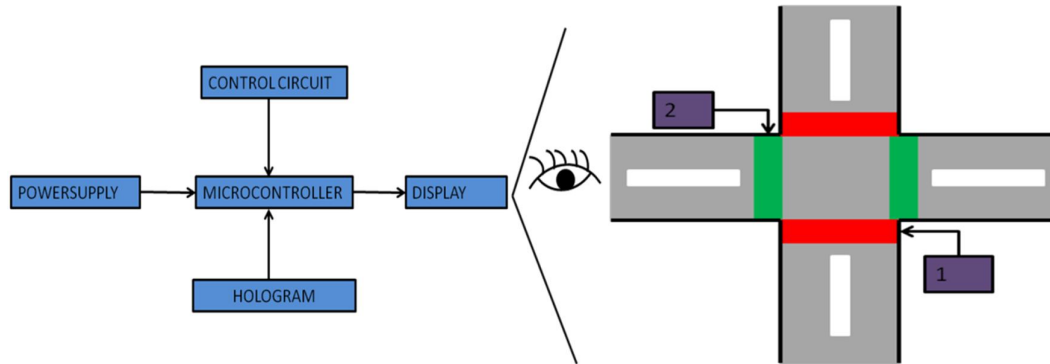


Figure 5. Block Diagram of Holographic Traffic Control System

Figure 6. Concept of Hologram Traffic Lights

This situation can also be better understood by flowchart in figure 7. Start and stop are the initial conditions of flow chart. Here checking of display condition is required. If the display is red, vehicles and pedestrians wait according to the timing given by control circuit. If the display is green, vehicles and pedestrians move according to timer.

IV. CONCLUSION

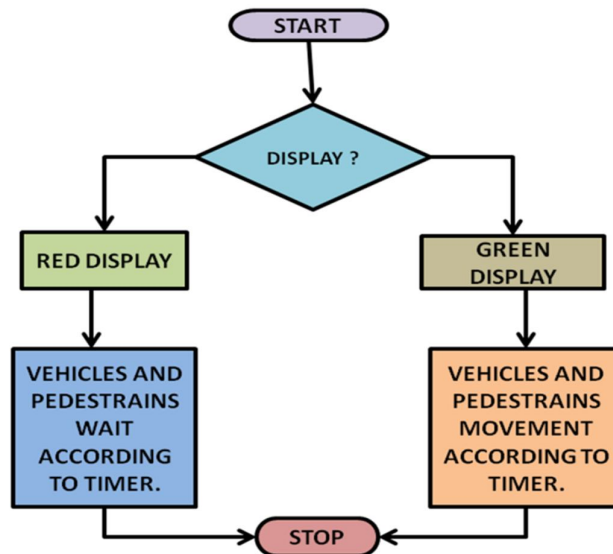


Figure7. Flowchart of Holographic Traffic Control System

This report is about the traffic light system and its limitations. In order to overcome those limitations hologram concept is introduced. Introduction, applications and techniques of holograms are discussed like hologram is a 3D image and it can be used in AR, VR along with techniques used are loss and lossless encoding. Hologram in corresponding working with camera and its working with various components are also discussed. This paper reports the concept of the hologram traffic lights from a concept of hologram to overcome the drawbacks of traffic light system. This paper discusses the block diagram and working model concept of hologram traffic signals. Beyond the block diagram of hologram traffic signals, it can lead to the implementation of it.

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