Title
Review Paper of Integrated structured light architectures

Author
Tran, Andrew

Publication Date
2022-12-13

Review Paper of Integrated structured light architectures

Andrew Tran, Undergraduate Electrical Engineering at University of California, Los Angeles. (Date: 12/5/22)

Abstract

Light has many optical phenomenons that are unique in nature. Science and engineering takes advantage of this by exploiting these phenomenons and uses them for a variety of applications. However exploiting these phenomenons is not easy and we are tasked to design and engineer tools to help us extract them. This research paper by Randy Lemons shows a generalized laser architecture that is designed to exploit and utilize light in the form of a laser to perform scientific experiments such as demonstrating light bullets.

Introduction

In the recent past and present day, optical phenomenons from light have shaped and advanced the way we live. Whether it be as simple as using it to help us see, transmitting information via fiber optics, or using it to help us identify cancer cells. We want to exploit these phenomenons for us to take advantage and build applications using them.

In Randy Lemons paper, it mentions that “Structured photonics lay the foundation for the generation or use of light with custom spatio-temporal variant field vector, amplitude, and phase distribution. [1]”. This means engineering systems that are capable of manipulating light to exploit their phenomenons are the foundation of photonics.

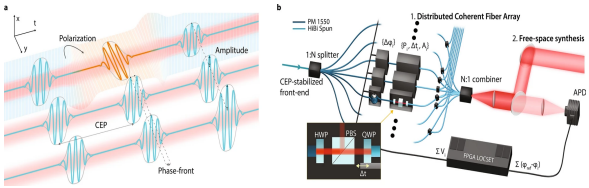
In order to engineer systems that use light to help achieve its objectives. It is important to understand how light operates in nature. We know that light is characterized by space and time dependence in the optical field. It is governed by Maxwell's equations which shows that the electric and magnetic fields are coupled together [2]. The basics on how light interacts with nature is dependent on the median it propagates through, the direction of the propagation wavevector, and the frequency at which it operates at.

There are already systems that take advantage of the basic nature of light and can manipulate in a way that may be useful for certain applications. For example, a common device to engineer structured light is using a spatial light modulator. This device can control the intensity and phase of a light beam in an image [1]. You can imagine a projector being a device that basically manipulates light in this kind of way.

However, as cool as a spatial light modulator may sound. We want to create more advanced systems that can manipulate light in different ways. One such system presented by Lemons is a generalized laser architecture that essentially shoots light bullets out [1].

Methodology

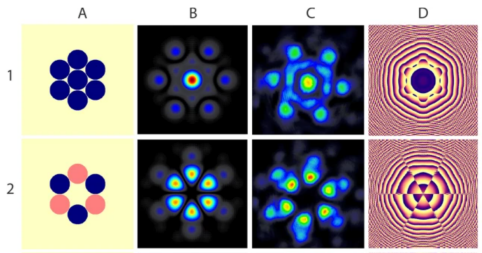
Lemons and his team designed the system by having a build-it programmable structure that helps exploit the light features to create bullets [1]. This system capitalizes on arrays called phased arrays that essentially carry individual waves each can be controlled independently [1]. The basic structure is seen below:



As seen above, this system uses fiber-based beamlines that are split. The front end of the system is a CEP which basically ensures pulse-to-pulse jitter [1]. The CEP needs to be stable as it is the first step into making sure a pulse-train can be achieved by the system [1]. One of the beamlines is used as a reference that is tweaked and maintained to ensure that the other beamlines may fall in line when need be [1]. After that every other beamline is then modified by its amplitude, polarization state and time before its delivery [1]. Each beamline has a phase modulator that is programmed by a user defined phase relationship with respect to the reference beam [1]. The intensity and polarization vector is controlled on each beamline using control units that have half wave plates, polarizing beam splitter and quarter wave plate; Each place at the pigtailed of the fiber [1]. The result of the beam essentially ends up in a photodiode to be spatio-temporally overlapped; the photodiode is used for optical detection. The resulting products are programmable laser pulses, in other words light bullets [1].

Results and Discussion

The result of this process produced by this light architecture is a beautiful display of different light patterns from 7 different beam channels. A subset of the display is seen below [1]:



The resulting image displays seven circular patterns and varies in intensity and shape. This shows that light can be manipulated in ways where different configurations are needed to achieve a certain goal. In this case the goal was to produce light bullets.

Conclusion

This paper showed a unique way where light can be manipulated and essentially tailored to meet a specific goal; in this case light bullets. But the end goal of photonics is not just to make light bullets. But to produce systems where the properties of light can be exploited in ways useful for applications of science and technology for the future to come.

References

[1]-Lemons, Randy, Liu, Wei, Frisch, Josef C., Fry, Alan, Robinson, Joseph, Smith, Steve R., & Carbajo, Sergio. *Integrated structured light architectures*. United Kingdom. https://doi.org/10.1038/s41598-020-80502-y

[2] -Liu, J.-M. (2017). *Principles of Photonics*. Cambridge University Press.