Optical Research Group

The appeal of the optical medium for communications, its tremendous bandwidth, is only fully exploitable through multiplexing of many signals, in time, wavelength, or other domain. Our research explores the use of signal processing, communication theory, and optical techniques in designing high capacity optical multiuser/multichannel systems and networks. Topics of current interest include: advanced modulation and coding for optical communication systems, cross-layer design and optimization of optical networks, ultraviolet non-line-of-sight communications, FSO and hybrid RF/FSO networks and communications, fiber-optic channel characterization, and signal processing for optical communication systems.

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"Designing communications systems to get more capacity with less cost and complexity."

UNIVERSITY of VIRGINIA
ENGINEERING

Optical Networks

The dramatic increase in throughput demands on transport systems has propelled the development of all-optical networks. These networks can have tremendous capacity when they are designed with their own limitations in mind, such as coarse wavelength granularity and physical impairments. In this research we consider the holistic design of optical networks that include the interdependence of three network layers: the traffic grooming layer, the lightpath management layer, and the physical fiber layer. The results of this work are practical algorithms for improved capacity and survivability of future optical networks as well as providing a quantitative proof of their superiority.

Optical Fiber Characterization

This research pursues the characterization of multiuser optical communication systems to increase the performance, distance, and capacity of existing and future systems. The focus is on the physical layer, i.e., the actual single fiber links that connect the nodes of large-scale networks. The intense demand for more data, voice, and video in and out of every home and office has led to multiuser systems that are typically broadband, high power, and long distance, sometimes leading to severe linear and nonlinear degradation in the signal due to properties inherent to the fiber. Our goal is to identify, characterize, and combat signal degradation in fibers, and to use this information to design the highest capacity multiuser systems.

Free-Space Optical (FSO) Communications

We are actively engaged in research involving UV communications, indoor visible-light systems, as well as RF/FSO hybrid networks. As inexpensive devices at UV wavelengths are becoming available, system designs are needed for improving the throughput and reliability of UV systems for use as the last-mile broadband connectivity in urban areas, densely-packed wireless sensor networks, and military applications. The same channel degradations can be found in indoor visible-light systems, where we investigate techniques to simultaneously satisfy communications and lighting needs. We are also working on FSO/RF networks designing systems that fully exploit the optical bandwidth to enhance RF wireless networks.

Signal Processing for Biomedical Time-Series Data

We are currently involved in a project in the area of body sensor networks (BSN) and signal processing within the context of two medical studies. Specifically, we are working to create a BSN platform and signal processing methods for quantifying changes in an individual's gait anytime and anywhere. This research will lead to fundamental advances in personalized medicine using signal processing that could be applied to any number of fields where relative assessment of variations is more important than absolute assessment.

RECENT RESEARCH DEVELOPMENTS

- Invented an optimal modulation scheme called Expurgated PPM for power-limited channels.
- Developed a discrete 2D model for WDM systems and used this model to design powerful coding and equalization techniques.
- Created an 'ant colony optimization' based grooming, routing and wavelength assignment algorithm for cross-layer design of optical networks.

RECENT GRANTS

- NSF – Multichannel Signal Processing for Dense Optical Communication Networks
- NSF – Ultraviolet Communication: Increasing the Distance-Rate Product
- NSF - Personalized Signal Processing for Early Diagnosis of Mobility Impairment

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