CASE STUDY /

Ansys + Özyeğin University

"Ansys Zemax OpticStudio allows us to easily design our optical communication systems, import the exact radiation pattern of the light source under consideration, and model the entire channel link, including the impact of reflection, scattering, and — in the case of outdoor and vehicular applications — weather conditions."

Hossien Eldeeb
Research Engineer / VISION ITN

CASE STUDY

Özyeğin University pioneers the use of Ansys Zemax OpticStudio for channel modeling in optical wireless communication

The main goal of the VISION's visible light communication (VLC) research is to develop technical and practical insights into the use of light fidelity (Li-Fi), a VLC technology that offers an alternative to Wi-Fi by running wireless communications based on light-emitting diodes (LED) transmission. "We're accustomed to thinking of light as providing illumination or power, but light can also carry information," said Hossien Eldeeb, a VISION ITN research engineer who helped lead the project as part of his Ph.D. candidacy in the Communication Theory and Technologies research group at Özyeğin's graduate department of Electronics and Electrical Communications Engineering. "Li-Fi innovates the use of light — which can be at either visible, ultraviolet, or infrared frequencies — to transmit a signal for communication."

/ Challenges

VISION structures its research around three main areas: smart cities, offices, and homes; manufacturing and medical; and smart transportation. For the latter of these, Özyeğin used OpticStudio to model and analyze optical channels for better understanding the safety and communications applications of using VLC technologies in vehicular transportation.

"When developing a VLC system, communication engineers need a realistic optical design that accounts for dedicated channel models," said Eldeeb. "To achieve this, they must consider the effect of all system parameters on the design — the light source, the photodetector, and any impacts on the flow of light across the channel."[4]

Additionally, using Li-Fi outdoors requires extra considerations. When designing a VLC system for use in an outdoor setting, the optical channel parameters are much harder to predict because any number of obstructions along a vehicle's route can influence the signal's transmission, such as sunlight,[6] precipitation, and reflections from other surfaces,[7] both stationary and in motion. Channel modeling for a VLC system, therefore, must account for this wide variety of possibilities in order to provide meaningful input into a system design.

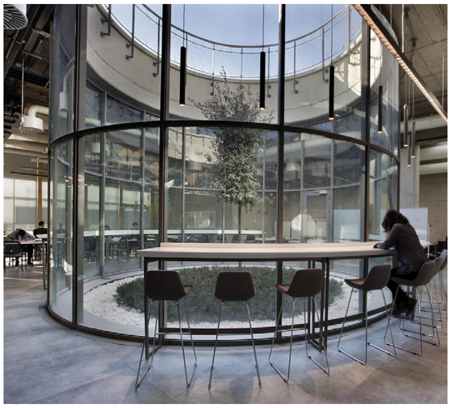
"When we set out to design VLC systems for Li-Fi vehicular communication, our team realized right away the challenges that would be involved due to the huge range of scenarios presented in outdoor environments,"[5] said Eldeeb. "We needed a methodology for modeling these scenarios reliably in an optical system design."

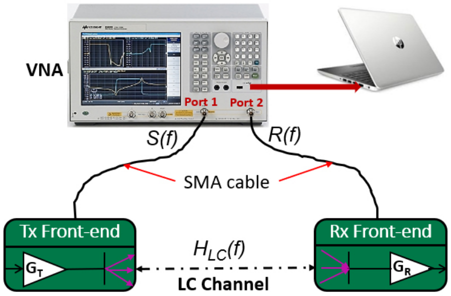
The most common channel modeling profile is the Lambertian diffuse model, but it proves inadequate for fully observing light sourcing and light behavior on diffuse, random surfaces in outdoor settings. Specifically, it doesn't meet the need for nonsequential ray tracing, which is necessary because of the nonsequential way light travels across a variety of unpredictable outdoor conditions.

"Considering that in a vehicular VLC system the outdoor lighting module is the transmit antenna, any modification of the antenna pattern naturally affects the communication performance," said Eldeeb.[10] "Vehicular VLC systems also differ from indoor scenarios due to the effects of sunlight[6] and weather conditions. So, we needed a professional ray tracing approach that could take into account all of these variables."

/ Ansys Products Used

- Ansys Zemax OpticStudio





Engineering Solution

Non-sequential ray tracing capabilities in OpticStudio made it possible for the Özyeğin vehicular VLC project team to conduct effective channel modeling. The software's built-in support and methodology for modeling Li-Fi channel activity, based on powerful non-sequential ray tracing algorithms and analytics for visualizing channel impacts, equipped the team with credible support for moving forward on their Li-Fi system design with a high degree of confidence.

"The main objective in optical wireless communication is to design the transmitter and receiver, which form the front ends of the optical system, and which you want to work perfectly in all channel cases," said Eldeeb. "So, to design this front end, you need OpticStudio. You cannot do it alone."

Other nuances afforded by OpticStudio's granular modeling and analysis capabilities included detailed definitions within the channel model for other incidental tparameters, such as the surface coating materials of obstructive elements, multiple properties of different precipitation types, and the potential scattering and diffusion of the light itself. By working with the Zemax features that carefully represent these parameters for modeling purposes — such as the scatter fraction (SF) parameter for determining the type of light being reflected and the Mie scattering model and other volume physics tools for modeling various weather conditions — Eldeeb and his team were able to fine-tune the outdoor vehicular VLC scenarios even further and conduct ray tracing with a high number of possible mitigating factors in mind.[5-7]

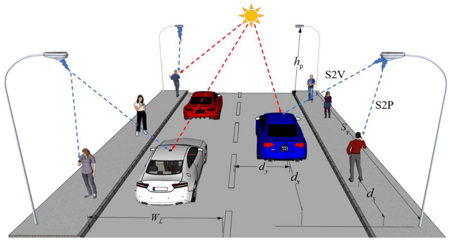
Results

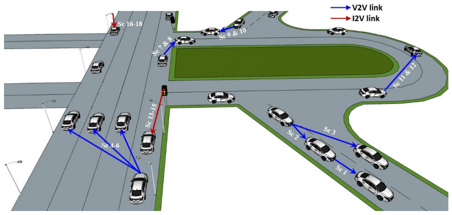
For the Özyeğin and VISION team, the outcome was very successful. "When we compared the results from our as-built system to the OpticStudio model we used during design," said Eldeeb, "we saw an outstanding match between the ray tracing approximations and the actual measurements that were produced by our vector network analyzer in Fraunhofer Heinrich Hertz Institute."[11]

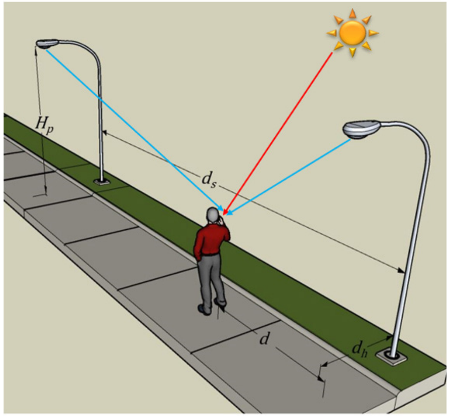
Eldeeb further emphasized that OpticStudio will continue to benefit his team on future projects, such as experimentation with utilizing different lens combinations to further optimize online wireless communication system designs. His organization is also looking at expanding its use of the Zemax software suite.

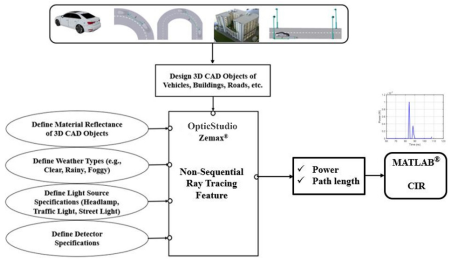
"We are very interested in adding OpticsBuilder," said Eldeeb. "As our research moves beyond channel modeling and gets into complete system design, OpticsBuilder would help us maintain an efficient workflow across our teams and projects."

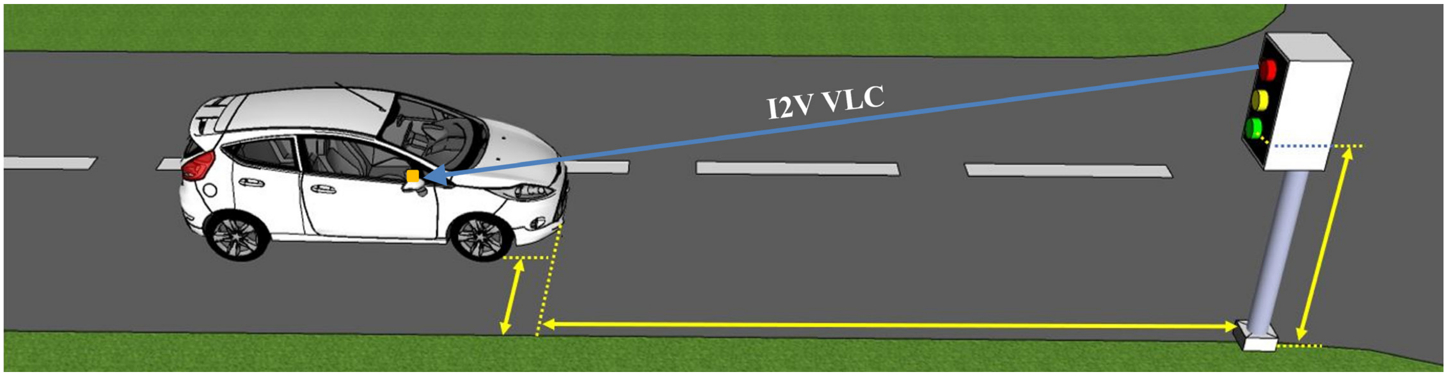
Most of all, the achievements of Eldeeb and his team show that optics, and the Zemax capabilities that support it, are expanding beyond the mechanical design of lenses and laser systems into whole new realm: light-based communications engineering. Channel modeling for Li-Fi and VLC using OpticStudio opens a new door to this emerging field of innovation, and the VISION ITN partners see Zemax as a key player in helping them discover what is possible.











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[6] H. B. Eldeeb and M. Uysal, "Visible Light Communication-Based Outdoor Broadcasting," 17th International Symposium on Wireless Communication Systems (ISWCS), 2021, pp. 1-6.

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