PADERBORN UNIVERSITY

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CCS

Master's Thesis

Modeling and Implementation of Outdoor Visible Light Communication Channel for IVC Applications

With the ever increasing demand of high speed connectivity, the typical Radio Frequency (RF) spectrum has already reached congestion level. In addition, the growing trend to improve road driving conditions through cooperative driving or Intelligent Transportation Systems (ITSs), which requires Inter-Vehicle Communication (IVC), is resulting in further dense util-

ization of already scarce RF spectrum. Recently, Vehicular Visible Light Communication (V-VLC) has emerged as a potential technology for IVC, and complements the existing RF-based vehicular communication. The possibility with V-VLC to support applications such as *platooning*, along with its low cost, and secure – RF interference free nature, has gain significant attention of the researchers and car manufactures.
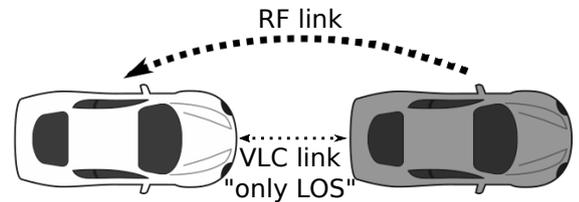
V-VLC utilizes the Light Emitting Diodes (LEDs) in a vehicle headlight for data transmission in the huge – license free visible light spectrum, and uses a simple photo-diode to receive the sent data. Due to the Line-of-Sight (LOS) requirement, V-VLC is considered relatively secure, and flexible in spectrum re-usability. Nevertheless, with all its advantages, outdoor Visible Light Communication (VLC) also pertains limitation due to distortion phenomenons caused by
a) The non-linear behavior of the LEDs (that can vary with material used),
b) Noise sources (i.e., thermal, quantization and shot),
c) Interference by ambient light sources (e.g., sunlight, streetlight, other cars, etc.),
d) Light dispersion over distance, and environmental effects (such as rain, fog, snow, dust, smog).

Goals of the thesis

The aforementioned distortive factors can be classified as channel impairments in VLC, and despite the growing interest in VLC, the literature on VLC channel modeling and characterization is rather limited. Most of the existing works are either on realistic channel measurements, which makes them very scenario specific and hard to reproduce, or they only consider very limited impairment factors for channel modeling.

In this thesis, the first step is to analytically study the existing VLC channel models (e.g. [1]), and the impact of distortion causing impairments on the transversing light. Later, based on the analytical study following tasks should be completed to successfully conclude the thesis:

- Derive a detailed VLC channel model that considers as much impairment factors as possible.

- Implementation of the derived channel model in GNU Radio for simulative evaluation, and for performance comparison with available studies on realistic VLC channel measurements, such as in [2].

Keywords

Channel Modeling, GNU Radio, Simulation, C++

[1]   Y. Qiu, H.-H. Chen, and W.-X. Meng, "Channel modeling for visible light communications—a survey," *Wireless Communications and Mobile Computing*, vol. 16, no. 14, pp. 2016–2034, 2016.

[2]   B. Turan, G. Gurbilek, A. Uyrus, and S. C. Ergen, "Vehicular VLC Frequency Domain Channel Sounding and Characterization," in *10th IEEE Vehicular Networking Conference (VNC 2018)*, Taipei, Taiwan: IEEE, Dec. 2018.

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