Demo: Visual MIMO based LED - Camera Communication Applied to Automobile Safety

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ABSTRACT

The inherent limitations in RF spectrum availability and susceptibility to interference make it difficult to meet the reliability required for automotive safety applications. To address this challenge, this work explores an alternative communication system called Visual MIMO that uses light emitting arrays as transmitters and cameras as receivers. Visual MIMO applied to vehicular communication proposes to reuse existing LED rear and headlights as transmitters and existing cameras (e.g. those used for parking assistance, rear-view cameras) as receivers. In this work we show a proof of concept based demonstration of the Visual MIMO system consisting of an LED transmitter array and a high-speed camera.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Wireless Communication*

General Terms

Design, Measurement, Experimentation, Performance

Keywords

Visual MIMO, Optical Wireless, Computer Vision

1. INTRODUCTION

Wireless RF based communications applied to automobile safety can be be susceptible to problems of high interference and limited spectrum availability. Instead, we propose a free-space optics approach called Visual MIMO [1] that uses light emitting arrays as transmitters (such as LED rear and headlights in vehicles) and cameras as receivers. Vehicles are increasingly using LEDs for daytime running and tail lights, as well as cameras (front and rear) that can record images of other vehicles lights. Computer vision based image analysis techniques can be used to spatially separate signals and remove interferences from distractors such as traffic lights, unlike conventional approaches that either use photodiode receivers [2] or complex hardware processing [3] .

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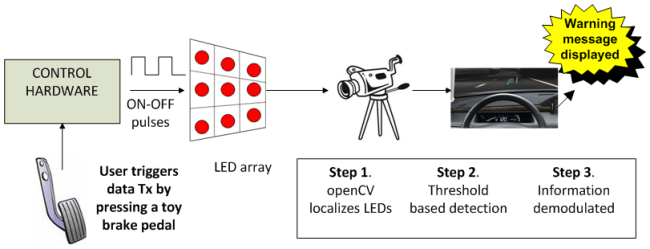

Figure 1: Visual MIMO demo block diagram

2. DEMO

An LED array (1), controlled by a microcontroller interfaced to a PC, is set to transmit a warning message along with the speed of the 'vehicle'in the form of ON-OFF pulses (ON = bit 1, OFF = bit 0) when triggered by an user. The LED array is controlled by a microcontroller interfaced to a PC and transmits the messages in the form of digital information using ON-OFF signaling. A high speed camera captures image frames of the array which are then individually processed and sequentially decoded to retrieve data and displayed on a receiver computer screen. To ensure successful data transmission even while in motion a tracking algorithm is implemented in OpenCV (Open source Computer Vision library). We will also demonstrate how such messages can be embedded so that they are nearly imperceptible for the human eye and how the camera view lends itself to determining a message source's location.

3. REFERENCES

[1] A.Ashok, M.Gruteser, N. B. Mandayam, J. Silva, K. Dana, and M.Varga. Challenge: Mobile Optical Networks Through Visual MIMO. In *Proceedings of ACM MobiCom '10*, pages 105–112, 2010.

[2] S. Kitano, S. Haruyama, and M. Nakagawa. Led Road Illumination Communications System. *VTC*, IEEE 58th, volume 5, pages 3346Ű3350, Oct. 2003.

[3] T. Saito, S. Haruyama, and M. Nakagawa. Inter-vehicle Communication and Ranging Method Using LED Rear-Lights. *Proceedings of Conference on Communication Systems and Networks*, 5:278–283, Aug 2006.