Speech Intelligibility Analysis of Sound-Modulated Laser Signal Countermeasures

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Surveillance devices using laser beams to detect sound are a security threat. The goal of this research was to quantify the ability of irregular transparent treatments to mask reflected modulated laser signals carrying human speech while ensuring good image quality. A laser, modulated by a recording of speech, was reflected off glass slides treated with materials that increased diffuse scattering. A photovoltaic receiver demodulated voice signals and a speech recognition software analyzed spoken words as a test of signal viability. An improved system for detecting vibration was explored to evaluate the masking effects. Clarity and transmission through treatments were assessed to ensure that treatments would mimic a window's attribute of transparency. In speech recognition tests, silica nanoparticle-epoxy resin treatment reduced words recognized to 47% compared to 100% for the control ($p<0.0001$). A polydimethylsiloxane(PDMS) and silica nanoparticle-dimethylsiloxane(DMS) treatment produced least intelligibility with 0% words recognized ($p<0.0001$). Transmission measurements at various wavelengths were analyzed spectrophotometrically and suggested that treatments did not reduce transmitted intensity significantly compared to the control. Clarity measurements were performed by comparing random pixel luminosities when a test image was viewed through the control and treated slides at various distances. All treatments except PDMS, which had a high average pixel luminosity of 77.2 lum, had low pixel luminosities and therefore preferred clarity. Overall, results suggest silica nanoparticle-DMS may offer a method of limiting intelligibility of laser-detected voice signals in near-specular reflection, while sufficiently maintaining both transmission throughput and image clarity.

Awards Won:

Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Intel ISEF Category

National Security Agency Research Directorate : First Place Award "Physical Science" $1000

Acoustical Society of America: Second Award of $1000, plus students School will be awarded $100 and Mentor awarded $250. Fourth Award of $500