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THE FRENCH AEROSPACE LAB

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PROPOSITION DE STAGE EN COURS D'ETUDES

Référence : **DOTA-2024-39**
(à rappeler dans toute correspondance)

Lieu : Châtillon/Palaiseau

Département/Dir./Serv. : DOTA/HRA, DOTA/SLS

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Responsable(s) du stage : Béatrice Sorrente, Matthieu Valla (ONERA), Frédéric Grillot (Télécom Paris)

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DESCRIPTION DU STAGE

Thématique(s) : Analyse de surface d'onde, Optique adaptative, Holographie numérique, Télécommunications optiques en espace libre

Type de stage : ☒ Fin d'études bac+5 ☒ Master 2 ☐ Bac+2 à bac+4 ☐ Autres

Intitulé : Exploring the temporal behavior of atmospheric fog with LiDAR techniques for wavefront shaping

Sujet :

Free space optical (FSO) communication in the infrared with quantum cascade lasers operating in the chaotic regime represents an attractive technology for secure terrestrial communication or ground-satellite communications in presence of atmospheric perturbations [1][2]. However in presence of atmospheric disturbances such as fog or clouds, the encoded information can be lost due to multiple scattering. The signal undergoes temporal and spatial distorsions, and becomes unreadable as the distance increases.

Fortunately a new generation of fast spatial light modulators integrating a high number of actuators allows now to address turbid media and paves the way for wavefront shaping techniques which partially correct scattering due to propagation through complex media [3]. These approaches which allows focusing and imaging of light through opaque medium could be applicated to FSO communications.

Recent works carried out by ONERA and the Laboratoire Kastler Brossel (LKB) show that the decorrelation time of the speckles that characterizes a fog can be compatible with the bandwidth of actuator mirrors available on the market. This means that it should be possible to implement a phase conjugation (time reversal) method for FSO through fog, a relevant technique to determine the optimal correcting field and avoid long calibration process of the channel.

The goal of this internship will be to characterize the temporal behavior of a beam after propagation through fog using LiDAR measurements. Indeed LiDAR technique can provide high resolution position of the scatterers and thus give access to temporal measurements. Futhermore LiDAR is a very advangateous technique since it allows easily deployable measurements thanks to the use of a fast single-pixel sensor compared to the use of a camera. ONERA has developed an unique expertise on LiDAR for various applications [4].

During his internship, the applicant will adapt the configuration of a LiDAR available in laboratory to perform experimental measurements in an optical set-up developed by ONERA. Temporal measurements will then be undertaken with a small green house representative of an atmospheric fog. From the data obtained with a combination of LiDAR measurements and advanced optical measurement techniques, interactions will be established between various temporal parameters of the turbid media in various atmospheric conditions. Data processing will enable the measurements to be compared with models derived from the theory of Brownian motion. The last step of the internship will be dedicated to the evaluation of the gain in spatial resolution brought by an innovative LiDAR concept developed by Telecom Paris and based on a chaotic signal. This evaluation will be based on the study of the error budget.

In such lidars the chaos is self-generated by a semiconductor laser therefore code generation and modulation of devices are not necessary. The chaotic lidar offer a much higher range resolution thanks to the broadband chaotic bandwidth. In addition, as the chaotic waveform never repeat itself, there is no range ambiguity in detection.

The research activities involved in the internship will include experimental tests and theoretical studies from a pre-selection of scientific papers. These works will take place as part of a collaboration between ONERA, Telecom Paris and the LKB

We are looking for an applicant with skills and interests in experimental work, as well as a taste for data processing and theoretical studies.

Bibliography :

[1] O. Spitz, A. Herdt, J. Wu, G. Maisons, M. Carras, C.-W. Wong, W. Elsäßer & F. Grillot, « Private communication with quantum cascade laser photonic chaos », Nature Communication.
[2] C. Sauvage, C. Robert, B. Sorrente, F. Grillot, et D. Erasme, « Study of short and mid-wavelength infrared telecom links performance for different climatic conditions », SPIE Remote Sensing,Strasbourg, Septembre 2019.
[3] S. Gigan, O. Katz, H. B. de Aguiar et al, « Roadmap on wavefront shaping and deep imaging in complex media », Journal of Physics : Photonics, Volume 4, Number 4, 2022.

[4] B Augere, B Besson, D Fleury, D Goular, C Planchat and M Valla, « 1.5 µm lidar anemometer for true air speed, angle of sideslip, and angle of attack measurements on-board Piaggio P180 aircraft », Measurement Science and Technology.

Est-il possible d'envisager un travail en binôme ? **Non**

Méthodes à mettre en oeuvre :

☒ Recherche théorique	☐ Travail de synthèse
☐ Recherche appliquée	☐ Travail de documentation
☒ Recherche expérimentale	☒ Participation à une réalisation

Possibilité de prolongation en thèse : **Non**

Durée du stage : Minimum : 5 mois Maximum : 5 mois (6 mois uniquement sur dérogation)

Période souhaitée : février-septembre 2024

PROFIL DU STAGIAIRE

Connaissances et niveau requis :	Ecoles ou établissements souhaités :
Optique, physique, modélisatisation	Ecole d'ingénieur ou master 2 avec spécialisation en optique/physique