

Subject: Can we use a Camera's Subtle Defects as Visual Cues for 3D Perception?

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Abstract (up to 10 lines):

3D computer vision has been successfully addressed by geometric and learning based methods. They both use idealised mathematical models of the camera, which are generally very good approximations of the physical phenomena. In this project, we would like to model all the subtle defects that real cameras possess, rather than discarding them, in order to improve 3D reconstruction. This is an original approach, which we will pioneer in this project. We will develop applications in healthcare.

Skills: coding, linear algebra, numerical optimisation, machine learning, 3D vision, medical image processing.

Keywords: computer vision, geometry, 3D reconstruction, healthcare.

Description (up to 1 page):

Beautifully efficient camera models exist for geometric and deep learning-based 3D vision. These models essentially describe the projection of a 3D point onto the image plane; they include the camera position, orientation, internal parameters, and are able to model optical distortion. They also model the formation of pixel colour, by carefully implementing an image rendering process.

However, they remain models. No matter how accurate they are, some optical phenomena will always escape them. Some core questions that we address in this project are about the nature of these unmodelled phenomena and their ability to constrain 3D image-based perception.

An initial lead is to study the fact that the image pixels are not acquired precisely at the same time frame. This is due to the individual sensor pixels' sensitivity and electronics. We will first set up controlled experiments to evaluate if these subtle effects can be reasonably measured. We will then develop calibration procedures and evaluate the stochastic and reproducible parts of the effects. Finally, we will include them in 3D reconstruction procedures by geometric and deep learning methods.

The methods will be used in healthcare, where cameras are increasingly used, for diagnosis and interventional gestures assistance, including surgery.

An internship will be planned in the partner university of Alcalá.

References (up to ½ page):

[1] **Passive Ultra-Wideband Single-Photon Imaging**

[Mian Wei](#)*, [Sotiris Nousias](#)*, [Rahul Gulve](#), [David B. Lindell](#), [Kiriakos N. Kutulakos](#)

<https://www.dgp.toronto.edu/projects/ultra-wideband/>

[2] <https://www.emergentmind.com/topics/rolling-shutter-structure-from-motion-sfm>

For more information on the surgical applications and the host team's work in this area, see:

- Webpage: <https://encov.ip.uca.fr>
- Publications: <https://encov.ip.uca.fr/publications>
- Commented augmented reality videos:
<https://www.youtube.com/channel/UCYO1dGfQXbYOHDlbdDis3HQ>

How to apply?

Email the supervisor.

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