Contexts:

Blind source separation (BSS) is a classic problem in the field of statistical signal processing. The objective is to estimate the source components from the observed mixtures without knowing the mixing process. BSS has found enormous success in several scientific fields such as acoustics and medical applications. At the same time, in recent decades, machine learning has opened the door to the analysis of more sophisticated signals, especially image sources thus motivating the need for image separation tools.

The proposed project aims to exploit new image characteristics to extend blind source separation to 2D (image) signals and to provide data processing tools for document restoration and artifact removal application in the field of medical imaging.

Being an inverse problem, BSS relies on the modeling of the mixing process and the prior information of the source signals. For 1D signals, several approaches are developed based on the properties of independence, sparsity, and non-negativity. Although these properties can be naturally extended to image signals, recently developed studies allow us to capture not only the statistical properties of images but also image-specific characteristics such as non-local property and high-level semantic understanding of images. Providing a data processing scheme for image separation is, therefore, a challenging task with potentially very high impact, especially for color images of which the mixing models have so far received much less attention. At the same time, the separation assessment is an important task where several studies have been carried out in objective and subjective ways for 1D signals. However, very limited work can be found for the assessment of image separation, although much research has been conducted on the measurement of visual quality based on human perception which has been an active area of research.

The proposed project targets two real-world applications: old document restoration and medical image artifact removal.

- Digital restoration of old handwritten documents: Old documents suffer from the problem of the show-through and bleed-through effect caused by the diffusion of ink from one side of a page to the other. In order to obtain sharp images from double-sided scanned documents, blind image separation is shown to be a very useful tool.
- Medical imaging: This involves removing specular reflection and smoke from laparoscopic surgery image sequences (videos). These artifacts are very inconvenient for the surgeon and at present, there is no effective solution. The source separation method will be tested on the VCL (Laparoscopic Surgery Video) database and submitted for evaluation by experts in the medical field.

The project gathers expertise on statistical signal processing, blind source separation, and image quality evaluation. Part of the research team has already been collaborating and aims at pushing further the promising preliminary results obtained in [].

Task 0: Project management
Coordination of regular meetings. Scientific presentations made by members of the project team to ensure knowledge spreading/sharing and discussions inside the research group.

Task 1: Machine learning for image characteristics and quality evaluation

Task 2: Multichannel model for color image separation

Task 3: Medical imaging data

A crucial aspect of this project is knowledge transfer of the medical imaging data.