Internship Master Proposal

Title : Blind image separation for video-guided laparoscopic surgery

Index - Blind image separation, video-guided laparoscopic surgery, desmoking, reflection removal, image enhancement

Introduction

Blind Source Separation (BSS) is a very active field of research in signal processing with a wide range of applications ranging from speech recognition systems, telecommunications, and biomedical signal analysis and diagnosis [1]. For a long time, it was limited to the 1D signal case and very little effort has been devoted to its application to multidimensional signals such as images. The objective of BSS is to estimate the source signals from some observed mixtures without (or with very little) information on the mixing process. Being an inverse problem, BSS relies on the prior information of the source signals. The recent theoretical work on BSS has built the bridge between machine learning and the nonlinear BSS [2] which enormously enlarged the scope of source separation. Furthermore, the use of generative adversarial networks (GAN) in the learning process opened new opportunities in BSS [3],[4].

Work description

The objective of the proposed work is to adapt the 1D model of the BSS technique to address the problem of blind image separation [5]-[7]. Although the BSS is a classic method for the grayscale image separation problem, color image mixing has so far received much less attention, mainly due to the challenges of the multichannel aspect of color images. Recently, the development of Independent Vector Analysis (IVA) [8], (8) improved largely the separation in the multichannel scenario for audio signals. We, therefore, propose to make use of and develop further the IVA framework for color image separation. This new path of research has the potential to improve the separation of color images thanks to the inter-channel information exploited by IVA.

We target the applications of BSS in the context of video-guided laparoscopic surgery. Laparoscopy is one of the most used minimally invasive surgery methods performed in the abdomen and pelvic area. However, the videos are affected by degradations that are superimposed on the signal, making the surgery task somewhat complicated and risky. This is essentially the smoke that appears during the surgery and the specular reflection on the organs and tissues. The smoking effect [9], which largely reduces the visibility of the organ, is commonly encountered during laparoscopic surgery due to the injected gas to facilitate the insertion of the endoscope and the surgical instruments in the incision. The specular reflection [10] is another annoying distortion in endoscopic videos caused by the light source reflections on the surface of the organ. One of the flexible solutions that does not require the addition of specialized equipment is to correct these annoying degradations by means of soft-ware solutions. More precisely, it consists in removing smoke and specular reflection from laparoscopic surgery videos using BSS techniques adapted to videos. We propose then, in this project, to study the modeling of the smoke and specular reflection problem within the framework of blind image separation and develop adapted approaches coupled with machine learning techniques in order to deal with various scenarios. The developed video quality enhancement and restoration solutions will be evaluated by means of dedicated video quality assessment metrics.

The first phase of this research work at both theoretical and practical level will be devoted to the extension of BSS models to the case of images by simulating mixtures. The second phase consists in studying smoke generation and specular reflection models in order to build realistic mixtures of degraded images and videos. The third phase will concern the adaptation and application of source separation methods to these data sets thus generated. And finally the final phase will be devoted to the evaluation of the restoration results using dedicated image and video quality metrics. During this introductory research course, the effort and time to be devoted to each phase will be measured and priority tasks will be adjusted according to the progress of the work.

References

1. Comon, P., Jutten, C. (eds.): Handbook of Blind Source Separation. Independent Component Analysis and Applications. Academic Press, Oxford (2010)
2. Hyvarinen, A., Sasaki, H., & Turner, R. (2019, April). Nonlinear ICA using auxiliary variables and generalized contrastive learning. In *The 22nd International Conference on Artificial Intelligence and Statistics* (pp. 859-868).
3. Y. C. Subakan and P. Smaragdis, "Generative Adversarial Source Separation," 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Calgary, AB, 2018, pp. 26-30.
4. Hoshen, Y. (2019, May). Towards unsupervised single-channel blind source separation using adversarial pair unmix-and-remix. In ICASSP 2019-2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 3272-3276). IEEE
5. W Souidène, A. Aissa El Bey, K. Abed-Meraim, Az. Beghdadi. Blind Image Separation using Sparse Representation. IEEE International Conference on Image Processing (ICIP), Sep 2007, San Antonio, United States. pp.125-128, ff10.1109/ICIP.2007
6. Abbass, M.Y., Kim, H. Blind image separation using pyramid technique. J Image Video Proc. 2018, 38 (2018). https://doi.org/10.1186/s13640-018-0276-8
7. A. Tonazzini, I. Gerace, and F. Martinelli, "Multichannel blind separation and deconvolution of images for document analysis,"IEEE Transactions on Image Processing, vol. 19, no. 4, pp. 912–925,2009
8. Feng, F., & Beghdadi, A. (2020, September). Reverberant Audio Blind Source Separation via Local Convolutive Independent Vector Analysis. In *2020 IEEE 22nd International Workshop on Multimedia Signal Processing (MMSP)* (pp. 1-6). IEEE.
9. Wang, C., Mohammed, A. K., Cheikh, F. A., Beghdadi, A., & Elle, O. J. (2019, March). Multiscale deep desmoking for laparoscopic surgery. In *Medical Imaging 2019: Image Processing* (Vol. 10949, p. 109491Y). International Society for Optics and Photonics.
10. Da Silva Queiroz, F., & Ren, T. I. (2014, August). Automatic segmentation of specular reflections for endoscopic images based on sparse and low-rank decomposition. In *2014 27th SIBGRAPI Conference on Graphics, Patterns and Images* (pp. 282-289). IEEE.

ADMISSION CRITERIA AND APPLICATION

- Master degree (2nd year level) or last year French engineering system degree in telecommunications, signal/image processing, computer science, or applied mathematics (other equivalent academic degrees would be considered on a case-by-case basis).
- Programming tool: Python, Matlab or OpenCv.
- Good English skill (both writing and speaking).
- CV and scanned copies of diplomas and grades from all academic institutions of higher education should be sent in ***a single zipped*** file to Dr. Fangchen Feng (fangchen.feng@univ-paris13.fr) and Prof. Azeddine Beghdadi (azeddine.beghdadi@univ-paris13.fr).

Supervisors

Prof. Azeddine Beghdadi

Dr. Fangchen Feng.

Hosting institution

The recruited candidate will be hosted at the Laboratoire de Traitement et Transport de l'Information (L2TI) at Université Sorbonne Paris Nord (USPN) in France.

Duration of the internship and internship allowance

– 4 to 6 months (depending on the date of recruitment)

– Internship allowance (gratification) according to the French legislation

With the possibility to apply for a PhD in the same topics at L2TI.