## Proposition de recherche doctorale

**Restauration de films anciens - Détection et correction des défauts persistants et inpainting spatio-temporel.**

**Mots clés :**
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- Unité de recherche : Laboratoire Traitement et Communication de l'Information
- Ecole doctorale : École Doctorale Informatique, Télécommunications, Electronique de Paris
- Domaine scientifique principal: Divers

## Résumé du projet de recherche (Langue 1)

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## Résumé du projet de recherche (Langue 2)

Digital restoration of audio-visual contents (films in particular) is an important task for the preservation, the diffusion and the exploitation of cultural heritage by different stakeholders: - Institutional archive keepers such as INA or CNC in France and BBC in the UK; - Content creators (movie studios) and/or distributors (TV broadcasters), as well as their service providers like Technicolor. From their shooting and their storage on films over extended time periods to their eventual digitization by film scanning, valuable contents undergo a number of degradations that can dramatically alter, if not preclude, playback experience. Repairing these degradations via manual restoration is an immensely tedious and time-consuming task (restoration of one movie can occupy as much as one year of a skilled person). Clearly, such manual processing can't be run over large scale archives and computerized automation is of paramount importance. However, after decades of research by the image processing community, automation is still partial and partially satisfactory: automatic detection of all defects and their seamless fixing irrespective of content type is not achieved by far. If full automation is arguably considered as simply beyond reach, advances in this domain are still eagerly awaited. A large variety of defects can affect movies. The two main types of them are blotches/dirt (an opaque or semi-transparent stain on a single image frame) and scratches (an opaque or semi-transparent trace from top to bottom of several successive image frames). Because the first type impacts a single frame at a time, intact content in previous and next frames can be used both to detect and repair defects with reasonable success. Scratches, on the contrary, affect several successive images, which makes their identification and removal more problematic, with the additional problem that their spatial extent is much larger than the one of blotches. The aim of this Ph.D work is to focus on non-impulsive defects that affect several frames and possibly over large regions, with scratches as the prototypical instance of such defects. Using most recent image analysis and processing techniques, we will address separately the automatic detection of such defects and their automatic removal. Envisaged roadmap includes: - Based on literature study and interactions with film restoration experts, build a taxonomy of non-impulsive defects to be attended. For each class, build specific multi-frame detectors that combine information on temporal, geometrical and topological characteristics of the class with information obtained through state-of-art motion estimation. In the case of scratches for instance, the challenge is to reliably detect them while ignoring vertical thin structures that really belong to the scene. - Design video inpainting algorithms to fill-in damaged regions (or detected as such) using a combination of motion-driven temporal interpolation and of spatial interpolation. Specific topology of defects could be exploited as well in the inpainting process. Special care will be paid to the problem of preserving the film grain, which is of key importance for high-quality restoration of videos and movies. This entails estimating the statistical characteristics of the grain of the shot to be restored and ensuring these characteristics are correctly reproduced in the inpainted regions (either by grain-free inpainting and posterior grain addition, or by grain-preserving inpainting). It is worth noting that both video inpainting and film-grain handling are largely open research topics that go way beyond the restoration task. Movies and professional video contents usually come at very large resolution (HD, UHD, 4k) and visual quality is of paramount importance when it comes to editing and restoring such contents. These two constraints will be particularly taken into account when designing the different algorithms mentioned above. Regarding the former, computational complexity will be carefully controlled with the help of most recent progresses in object detection (cascaded detection, branch and bound pruning), motion estimation (sparse/dense real time optical flow on gpu) and inpainting (rapid search and decomposition of image patches using modern learning techniques, pde solving on the gpu, instant Poisson cloning). Regarding visual quality, grain management mentioned above will be a crucial ingredient. Temporal consistency will also be enforced as much as possible to get rid of ghosting that affect current scratch removal systems (and video inpainting at large). On a different front, special care will be paid at detection stage to the delicate compromise between precision and recall, depending on the amount and type of manual intervention that is allowed, on the type of defects and on the type of data. Specific machine learning tools could be mobilized to this end. On a longer term, introducing appropriate scene understanding (e.g., face and facial feature identification) or saliency modeling could help focus on highest risk false alarms. Designed algorithms will be implemented in Matlab and/or C++ and validated on a variety of real archive films provided by Technicolor and TelecomParisTech through their respective partners in the domain of film restoration.