Research Summary – A. Almansa

I contributed **58 peer reviewed papers** in mainstream journals and conferences in image processing (23 in international journals, 33 in proceedings of international conferences, and 2 as contributed book chapters) with an overall number of **727 citations** and an **h-index of 12**.[1] I am in the **editorial board** of the IPOL journal, and I serve as a regular reviewer in all the major journals in mathematical imaging, and as an organizer of international workshops that attracted top researchers in my field. I have supervised **9 PhD thesis** (+5 ongoing) and **2 postdocs**, all of which currently hold research positions in the most renowned imaging research labs. I secured **12 competitive grants** in the last 10 years, most of them as the PI, including an EU funded ALFA network and several ANR and CNES grants. In all of my publications I am either the main or the most senior contributor except for the period 2004-2010, where many of my works were co-authored with JM Morel and V. Caselles, as a result of my effort to build an international research network via co-supervised research training (ALFA, ECOS and STIC AmSud projects) between Uruguay, France and Spain. As a result, my research group in Uruguay became a leading image processing team in Latin America.

Research interests and impact.

My most visible contributions have been both methodological and applied, at the interface between variational and statistical image restoration and visual perception models, and its applications to the optimization of imaging and stereovision systems in remote sensing, digital photography and film postproduction. Here is a summary of 10 selected contributions:

1996-2003 Pre-PhD contributions (not co-authored with PhD supervisor): My earliest contributions can be divided in three areas:

- My work on *fingerprint* image matching [C4] and *restoration* [**J4**,B1] cumulates more than 200 citations over 15 years. a) it provides a highly accurate parameterless algorithm to restore fingerprint images, and estimate low level characteristics (ridge width & orientation), and b) it contributed to develop and showcase the power of the *affine gaussian scale-space theory*, providing the necessary tools to develop affine invariant versions[1] of the SIFT descriptor which became extremely popular in computer vision.
- My work on *vanishing point detection* [**J6**] transformed the "semi-manual" single image metrology methods of Criminisi (Oxford & Microsoft) into a complete computational theory allowing the automation of 3D reconstruction algorithms. L. Rudin (author of the celebrated pioneering work on Total Variation) immediately integrated this in his VideoInvestigator software at Cognitech Inc., which has been sold to hundreds of police departments in the world.
- My work on *image resolution measures and antialiasing restoration* [**J7**] provided the Fourier analysis and information-theoretical background required to produce artifact-free images and to guide optimal design choices for the SPOT5 earth observation satellite. It also greatly influenced the design of its successors Pleiades and OTOS, and more generally, it constituted a precursor of the ever-increasing computational imaging field.

2004-2010 Post-PhD contributions (international network builder): Research in this period was to a large extent motivated by *(i)* a collaboration with the French Space Agency (CNES) on the design of remote sensing imagers with low baseline stereoscopic vision, and by *(ii)* the construction of an international research network to address this problem. The network spawned Uruguay (where I held a professor position), France (my PhD supervisor's team) and Spain (V. Caselles team).

- *Mathematical modeling of perceptual visual grouping*: My early work on vanishing point detection [**J6**] contributed to the early development of Desolneux's probabilistic (*a contrario*) theory of visual perception [2], in particular to model and circumvent the *masking effect*. A generalization of this idea [**P1**,J12] provided the first general clustering algorithm that could solve Jain's 2010 challenge [3]. My other contributions to the field concern the statistical and algorithmic modeling of collaboration and conflict of partial gestalts like contrast vs. good continuation in *perceptual contour detection* [J18,J20,C20,C31], and the *perceptual similarity of image patches* [**J14**].
- *Subpixel stereovision & restoration from irregular samples*: My research within the MISS project focused on the feasibility of 1/10th to 1/100th pixel accurate disparity maps, required for sub-meter-accurate digital elevation models in urban areas from low-baseline stereoscopy as provided by Pleiades, and future CNES imagers. We showed that such accuracy requirements are close to information-theoretic bounds [**J13**,C12], and that they can be met at about 50% of the pixels, once unreliable areas have been automatically rejected by a statistical criterion [**J14**, C15]. This technique was found to greatly improve the accuracy of state-of-the-art production software used at CNES and IGN [C17]. It also was a key element that allowed our colleagues at IMAGINE (ENPC) to win NASA's PRoVisG Mars 3D Challenge.

[1] All citation numbers in this section were obtained from Google Scholar on Dec 27th 2015 and corrected to **exclude self-citations** using CIDS 3.0 beta. Details available at http://perso.enst.fr/~almansa/publications/

- Such accuracy levels are only possible if satellite microvibrations are first estimated and corrected a posteriori. This is an ill-posed inverse problem requiring the joint use of *non-harmonic analysis, variational methods,* and *statistical non-smooth optimization* [J8,**J10**,J11,C16].
- In the process, a precise knowledge of the *subpixel blur kernel* is required. We show theoretically [**J16**] and with an online algorithm [J15] that *subpixel kernel estimation* from a single snapshot is possible if a particular calibration pattern is used. If a second rescaled snapshot is available, the pattern may be unknown and some deviations from the optimal pattern are admissible with a minor performance loss [J17,J19].

2011-2015 Multi-Image processing and Patch-Based Methods (group leader): Since 2011, my research was again not co-authored with my former PhD supervisor, and I consolidated my own research team as a permanent scientist at LTCI. In this period I broadened my application interests and industrial collaborations to include digital photography (DxO Labs) film postproduction (Technicolor R&I) and surface reconstruction from point clouds. From a methodological viewpoint I strived to broaden the applicability of *sparsity* and *patch-based* models of natural images, videos and surfaces, while deepening our understanding of their fundamental limits and approximation properties.

- This is achieved for *multi-image super-resolution* [P2,C19] where we extend theoretical well-posedness bounds to more general motions, and show how these predictions can be used to preserve more details by automatic fine-tuning of local regularization parameters. We also show that simultaneous *super-resolution and outlier detection & restoration* is possible [**J23**,C29,C25] under sparsity constraints on the outlying artifacts that are closely related to the null-space property commonly used in *compressed sensing*. Applications of these bounds to outlier removal in remote sensing are explored in [C18].
- Concerning *patch-based methods*, my recent work provided: (i) *accelerated example-based* video inpainting [**J22**] and *accelerated learning of gaussian mixture models* [**C32**] for image restoration and (ii) new insights into the kinds of distances that should be used to compare similar image patches in order to broaden their applicability to more difficult inverse problems like *single-shot HDR imaging* [**C33**] or *dynamic texture synthesis* [**J22**]. The resulting video inpainting algorithm sets a new standard in terms of quality and algorithmic complexity that was the object of both a patent application and software publication.

My recent work on sparsity and patch-based methods received a significant attention from the academic community. As a consequence during the **last 2 years** I accepted **2 keynote and 5 invited talks** in international workshops and conferences, and I started a new seminar to attract smart scientists to discuss about the future of non-local image restoration in our lab.

	Selection of 10 significant & recent publications[2] *	# cited [3]	Journal impact[4]
J23	Traonmilin, Y., Ladjal, S., & Almansa, A. (2015). **Robust Multi-image Processing with Optimal Sparse Regularization**. *Journal of Mathematical Imaging and Vision*	2	27
J22	Newson, A., Almansa, A., Fradet, M., Gousseau, Y., & Pérez, P. (2014). **Video Inpainting of Complex Scenes**. *SIAM Journal on Imaging Sciences*.	17	36
C32	Guillemot, T., Almansa, A., & Boubekeur, T. (2014). **Covariance Trees for 2D and 3D Processing**. In *CVPR 2014*, [acceptance rate 5.76%]	-	118
C33	Aguerrebere, C., Almansa, A., Gousseau, Y., Delon, J., & Muse, P. (2014). **Single shot high dynamic range imaging using piecewise linear estimators**. In *(ICCP 2014)*	4	12
J16*	Delbracio, M, Musé, P, Almansa, A, & Morel, JM (2011). **The Non-parametric Sub-pixel Local Point Spread Function Estimation Is a Well Posed Problem**. *IJCV*.	8	58
J14*	Sabater, N., Almansa, A., & Morel, J.-M. (2011). **Meaningful Matches in Stereovision.** *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *34*(5)	21	104
J10	Almansa, A., Ballester, C., Caselles, V., & Haro, G. (2007). **A TV Based Restoration Model with Local Constraints.** *Journal of Scientific Computing*.	32	27
J7	Almansa, A., Durand, S., & Rougé, B. (2004). **Measuring and Improving Image Resolution by Adaptation of the Reciprocal Cell**. *J. Math. Imaging & Vision*, *21*(3).	25	27
J6	Almansa, A., Desolneux, A., & Vamech, S. (2003). **Vanishing point detection without any a priori information**. *IEEE Trans. Pattern Anal. & Machine Intelligence*, *25*(4).	144	104
J4	Almansa, A., & Lindeberg, T. (2000). **Fingerprint enhancement by shape adaptation of scale-space operators with automatic scale selection**. *IEEE Trans. Image Proc*.	140	75

[2] Publications co-authored with my PhD supervisor are marked with *. They are all the result of a post PhD collaboration (student co-supervision).
[3] Citation numbers were obtained from Google Scholar on Dec 27th 2015 and corrected to **exclude self-citations** using CIDS 3.0. Details available at http://perso.enst.fr/~almansa/publications/
[4] The h5-index measures the impact factor of a journal or conference. https://scholar.google.fr/intl/en/scholar/metrics.html - metrics

Notations pour les références bibliographiques.

Dans tout le document j'utilise la notation suivante pour discriminer les références bibliographiques dont je suis auteur de celles dont je ne suis pas auteurs:

Les ***publications dont je ne suis pas auteur*** sont références sous la forme [xx] où xx et un chiffre entier. L'ensemble de sources citées est listé à la fin du document. La seule exception à cette règle sont les thèses que j'ai encadrée qui sont référencées sous la forme [Txx].

Les ***publications dont je suis auteur*** prennent une forme qui permet de distinguer le type de publication:

[Pxx] Prépublications, rapports et articles en cours d'évaluation (*preprint*)
[Jxx] Articles parus dans des revues scientifiques internationales avec comité de lecture (*journal*).
[Bxx] Livres ou Chapitres dans des livres (*book*).
[Cxx] Articles de conférences internationales avec comité de lecture (*conference*)

La liste complète de mes publications constitue la partie 2 de ce dossier de candidature et peut également être consultée en ligne.[5]
Quand plusieurs références bibliographiques sur des sujets similaires sont citées ensemble, la plus significative est indiquée en **gras**. Une sélection de mes 10 publications les plus significatives est aussi systématiquement citée en **gras**.

Références Bibliographiques

[1] K. Mikolajczyk and C. Schmid, “An affine invariant interest point detector,” *Comput. Vis. - ECCV 2002*, vol. 2350, pp. 128–142, 2002.
[2] A. Desolneux, L. Moisan, and J. M. Morel, *From gestalt theory to image analysis: a probabilistic approach*. Springer Verlag, 2008.
[3] A. K. Jain, “Data clustering: 50 years beyond K-means,” *Pattern Recognit. Lett.*, vol. 31, no. 8, pp. 651–666, Sep. 2010.

[5] http://perso.telecom-paristech.fr/~almansa/publications/