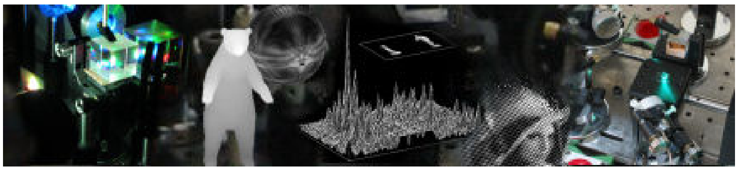
SCIENTIFIC/TECHNICAL RECORD OF THE OPTO-ELECTRONIC IMAGE PROCESSING GROUP FROM 2008 UNTIL 2013

The Group of Optoelectronic Image Processing (GPOEI) from the University of Valencia (http://www.uv.es/gpoei/) started its activity in optical and digital image processing in 1995. Since then, the group has demonstrated a wide and dilated experience which is supported by over 100 peer reviewed publications only in the last decade.



Nowadays, GPOEI is made up by 5 members (2 Full Professors, 1 Associate Professor, 1 Assistant Professor and 1 Hiring Advanced Technician). Here is a summary of the main GPOEI Research Group activities during the last 5 years, approximately.

1. MEMBERS

FULL TIME PROFESSORS:

- Dr. CARLOS FERREIRA GARCÍA, Full Professor of Optics
- Dr. JAVIER GARCÍA MONREAL, Full Professor of Optics
- Dra. PASCUALA GARCÍA MARTÍNEZ, Associate Professor
- Dr. VICENTE MICÓ SERRANO, Assistant Professor (from 2009 until nowadays)

PhD STUDENTS:

- MARTÍN SANZ SABATER
- LUIS GRANERO MONTAGUD.

EXTERNAL COLLABORATORS:

RESEARCH GROUPS:

- Research group of Prof. ZEEV ZALEVSKY: http://www.eng.biu.ac.il/zalevsz/, School of Engineering, Bar-Ilan Univ., Ramat Gan, 52900, Israel.
- Research group of Prof. BAHRAM JAVIDI: http://www.ee.uconn.edu/faculty.php?f_id=13, Departament of Electrical and Computer Engineering, University of Connecticut, USA.
- Research group of Prof. DAN COJOC: http://www.tasc.infm.it/research/om/scheda.php, Consiglio Nazionale delle Ricerche – Istituto Officina dei Materiali.
- Research group of Prof. IGNACIO MORENO SORIANO, Departamento de Ciencia de Materiales, Óptica y Tecnología Electrónica, Avda. Universidad, s/n. Edif. Torrevaillo - ELCHE – 03202.

COLLABORATIVE SCHOLARSHIP STUDENTS (private funding):

- LUIS CAMACHO TORRENTE, Topic: Imagen cuantitativa de fase en microscopía no holográfica usando un modulador espacial de luz. Duration: 2009-2010.
- ALEJANDRO CALABUIG BARROSO, Topic: Microscopía interferométrica superresolvente 1D de única exposición mediante multiplexado en RGB. Duration: 2010-2011.
- BEATRIZ PERUCHO FLECHOSO, Topic: Técnicas optoelectrónicas de evaluación y monitorización de diferentes parámetros físicos (2012).

HIRING ADVANCED TECHNICIAN:

- STANISLAV KOLPAKOV as member of the CRAFT EU Project titled “BRIGHTLIGHT. Periodic dispersive photonic components for control of spectral, spatial and temporal characteristics of laser diode radiation” from 2007 to 2008.
- MARTÍN SANZ SABATER (private funding), as internal collaborator on opto-phone technology (2011 to nowadays).

FOREING STUDENTS:

- CARLOS JESÚS JIMÉNEZ RUIZ, Universidad De La Guajira, Colombia, Duration: 2 months (2011).
- HUGO CABON, IUT de Lannion, Lannion (France), Duration: 2 months (2011).

2. SCIENTIFIC PRODUCTION

MAIN RESEARCH AREAS:

OPTICAL SUPERRESOLUTION: DIFFRACTIVE AND GEOMETRICAL METHODS.

Superresolution is one of the most fascinating and applicable fields in optical data processing. The urge to obtain highly resolved images using low quality imaging optics and detectors is very appealing. The field of superresolution may be categorized into two groups: diffractive and geometrical superresolution. The first one deals with overcoming the resolution limits dictated by the diffraction laws and are related to the numerical aperture of the imaging lens. The second field overcomes the limitation determined by the geometrical structure of the detector array. The improvement is thus made at the price of sacrificing unused degrees of freedom such as time, wavelength, polarization or field of view depending on the a priori available information about the object to be imaged. The development of new approaches and configurations to get superresolved imaging in its wide sense is of special interest inside the group.

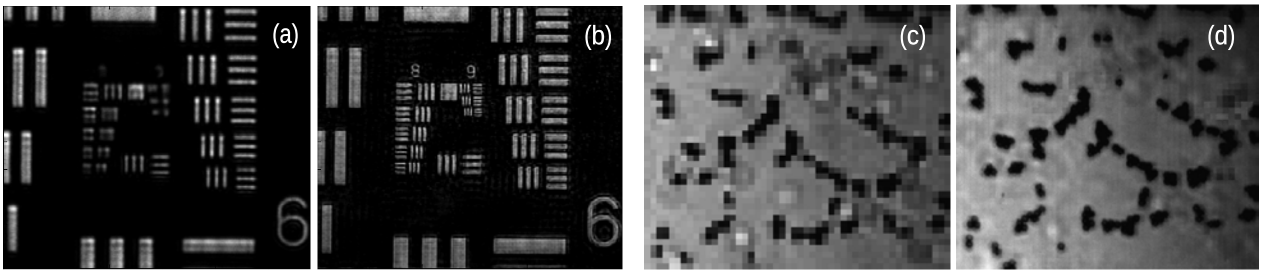


Figure 1: Some examples of superresolved images using optical (a-b) and geometrical (c-d) superresolution strategies. Images (a) and (b) are obtained Ref. 1 and correspond with a USAF resolution test target (minimum size of 1.5 microns) while images (c) and (d) are extracted from Ref. 2 and correspond with fluorescent microbeads (10 microns in diameter).

QUANTITATIVE PHASE AND 3D IMAGING: PHASE RETRIEVAL AND RANGE IMAGING.

Three-dimensional (3D) quantitative imaging of micro- and macro-structures and their dynamics could find numerous applications in many fields such as 3D metrology, pre- and post-production control, object recognition, cell biology and medicine, just to cite a few. Inside of our group, we are interested in the development of new methods for quantitative phase and 3D imaging. We have been mainly focused to the fields of microscopy (quantitative phase imaging) and 3D mapping by remote sensing. Quantitative phase imaging in microscopy deals with the capability of phase retrieval by using interferometric or non-interferometric approaches. Since the phase distribution transmitted by a sample contains information of both the surface profile as well as the internal distribution of the sample (changes in the refractive index values), phase retrieval provides extremely useful information of the sample under test. 3D mapping and range measurement deals with the analysis of objects in the far field and permits 3D representation and object recognition based on the retrieved 3D information.

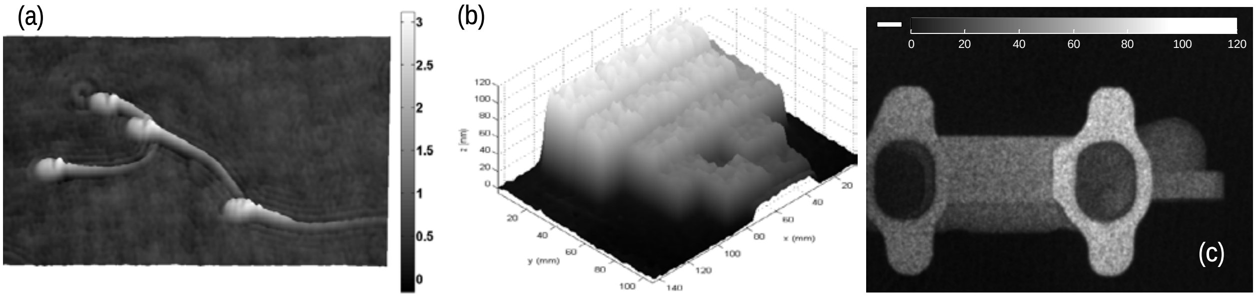


Figure 2: Some examples of 3D and range images. Image (a) shows quantitative phase imaging of a group of swine sperm cell, and image (b) and (c) represent a 3D view and a range image of a 3D object built from single blocks of a toy object and for a gas collector prototype of an engine, respectively. See Refs. 33 and 34 for a detailed description.

REMOTE MONITORING OF SOUND (OPTO-PHONE) AND BIOPARAMETERS USING SPECKLE METROLOGY

The ability of dynamic extraction of remote sounds is very appealing for a wide range of applications ranging from homeland security to sensational press. We have developed in collaboration with the group of Prof. Zeev Zalevsky from the Bar-Ilan University, a novel technology for remote estimation of the sound. It is based on the analysis of speckle patterns that are recorded with proper optics. Then, by digital image processing tools it is possible to translate the vibration/tilting profile of the surface under analysis into sound. Since the technology acts essentially as a transducer element that enhances the vibration profile of the surface being inspected, changes in the vibration profile can be traced by analyzing changes in the reflected speckle pattern. Thus, the technique is not only valid for speech analysis but also for identifying obscure or camouflaged objects, for tracking cells with nanometric accuracy, as well as for monitoring bio-parameters such as glucose level, heart rate, intra-ocular pressure, alcohol level in blood, etc. And it is possible (depending on the application) to adapt the proposed technology to a given application by using low cost components.

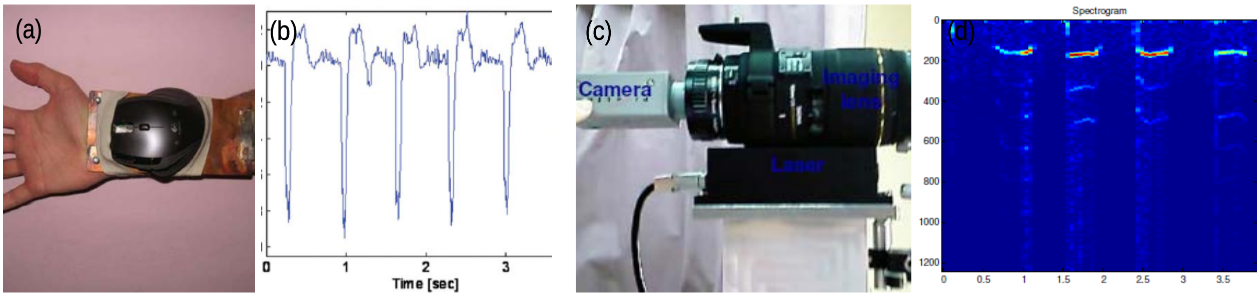


Figure 3: Two examples of the technology used for the extraction of biological parameters (a-b) as well as for remote monitoring of sound and vibrations (c-d). In (a) the technology is adapted using conventional PC mouse components and in (b) we can see the measured heart beat profile. Image (c) shows the layout for remote monitoring of sound/vibrations while (d) depicts the spectrogram for the recorded voice pattern. See Refs. 35 and 41 for a complete description of the experiments showed above.

LENSLESS MICROSCOPY

Digital in-line holographic microscopy (DIHM) in combination with numerical imaging reconstruction proposes an extremely simplified layout while retain the advantages provided by holography with enhanced capabilities derived from digital processing algorithmic. DIHM supposes a modern realization of the original idea proposed by Dennis Gabor in 1949 where an imaging wave caused by diffraction at the sample plane interferes with a reference wave incoming from the non-diffracted light passing through the sample and the result is recorded by an electronic imaging device. DIHM has been the cornerstone of a new kind of holographic microscopes that have some advantages (such as pricing, compactness, dimensions and handling) regarding conventional holographic microscopes. Nevertheless, they still retain some disadvantages such as relatively modest numerical aperture, limited sample range applicability, noise, etc. It is the aim of our group to push on the development of new techniques capable of improving performance in lensless microscopy.

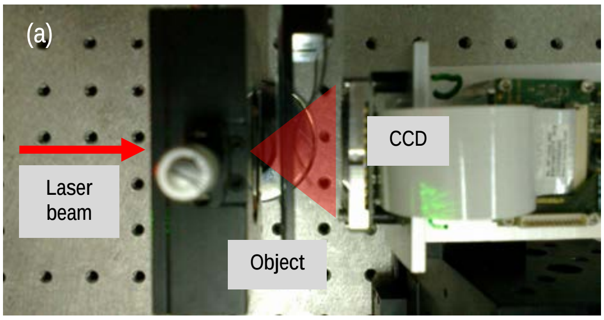


Figure 4: (a) Basic layout picture of a lensless imaging system at the lab where a laser beam impinges onto a pinhole aperture and the diffracted beam reaches the CCD at few millimeters from it after passing through the object to be imaged; (b) recorded holographic image provided by the CCD, and (c) recovered object image after numerical propagation. See Ref. 45 and 46 for more information.

POLARIZATION IMAGING AND SLM CHARACTERIZATION

The development of novel techniques and algorithms for the recording, processing and identification of 3D imaging based on polarization is also a research area in the group with contributions along the past years. Thus, we are interested in the design and implementation of polarimetric optical correlators, use of polarization states for coding/decoding the object information, optical and digital 3D image processing for detection and identification of objects, and the use and characterization of liquid crystal displays (mainly Spatial Light Modulators) in optical layouts. In particular, the use of SLMs in optical setups provides an extremely versatile tool for implementing a wide range of optical processing methods such as phase contrast and DIC in microscopy, phase shifting interferometry, computer generated holograms, applications based on optical encryption, adaptative optics for aberration correction, etc.

Here are some of the main outputs of our group concerning the previous research areas:

LIST OF PEER REVIEWED PUBLICATIONS:

- ON SUPERRESOLUTION:

1. V. Mico, Z. Zalevsky, and J. García, “Synthetic aperture microscopy using off-axis illumination and polarization coding,” Opt. Commun. 276, 209-217 (2007).
2. D. Fixler, J. Garcia, Z. Zalevsky, A. Weiss and M. Deutsch, “Pattern projection for subpixel resolved imaging in microscopy,” Micron 2, 38, 115-120 (2007).
3. Z. Zalevsky, E. Saat, S. Orbach, V. Mico and J. Garcia, "Exceeding the resolving imaging power using environmental conditions," Appl. Opt. 47, A1-A6 (2008).
4. Z. Zalevsky and J. Garcia, "All-Optical Super Resolved and Extended Depth of Focus Imaging with Random Pinhole Array Aperture," Opt. Commun. 281 (5), 953-957, (2008).
5. V. Mico, O. Limon, A. Gur, Z. Zalevsky and J. Garcia, "Transversal Resolution Improvement using Rotating Grating Time Multiplexing Approach," JOSA A 25, 1115-1129 (2008).
6. J. García, V. Micó, D. Cojoc and Z. Zalevsky, "Full Field of View Superresolution Imaging based on Two Static Gratings and White Light Illumination," Appl. Opt. 47, 3080-3087 (2008).
7. V. Micó, Z. Zalevsky, C. Ferreira and J. García, "Superresolution digital holographic microscopy for three dimensional samples," Opt. Exp. 16, 19260-19270 (2008).
8. V Micó, J. García and Z. Zalevsky, "Axial superresolution by synthetic aperture generation," JOPA A 10, 125001 (2008).
9. V. Mico, Z. Zalevsky and J. Garcia, "Optical superresolution: imaging beyond Abbe’s diffraction limit," Journal of holography and speckles 5, 7-14 (2009).
10. Z. Zalevsky, V. Mico and J. Garcia, "Nano photonics for optical super resolution from an information theoretical perspective: a review," J. of Nano Photonics 3, 032502 (2009).
11. V. Mico, J. Garcia and Z. Zalevsky "Quantitative phase imaging by common-path interferometric microscopy: application to super-resolved imaging and nanophotonics," J. Nano Photonics 3, 031780 (2009).
12. D. Sylman, Z. Zalevsky, V. Micó, C. Ferreira, J. García, “Two-dimensional temporal coherence coding for super resolved imaging,” Opt. Commun. 282, 4057–4062 (2009).
13. Z. Zalevsky, E. Fish, N. Shachar, Y. Vexberg, V. Micó and J. Garcia, "Super resolved imaging with randomly distributed, time and size varied particles," JOPA A 11, 085406 (2009).
14. L. Granero, V. Micó, Z. Zalevsky and J. García, "Superresolution imaging method using a phase-shifting digital lensless Fourier holography," Opt. Exp. 17, 15008-15022 (2009).
15. V. Micó, L. Granero, Z. Zalevsky and J. García, "Superresolved phase-shifting Gabor holography by CCD shift," JOPA A 11, 125408 (2009).
16. D. Sylman, Z. Zalevsky, V. Mico and J. Garcia, "Super-Resolved or Field of View Enlarged Imaging based upon Spatial Depolarization of Light," Opt. Commun. 283, 1715-1719 (2010).
17. L. Granero, V. Micó Z. Zalevsky and J. García, “Synthetic aperture superresolved microscopy in digital lensless Fourier holography by time and angular multiplexing the object information,” Appl. Opt. 49, 845-857 (2010).
18. V. Micó and Z. Zalevsky, “Superresolved digital in-line holographic microscopy for high resolution lensless biological imaging,” J. of Biomedical Optics 15(4), 046027 (2010).
19. D. Sylman, V. Micó, J. García and Z. Zalevsky, “Random angular coding for superresolved imaging,” Appl. Opt. 49, 4874-4882 (2010).
20. A. Gur, D. Fixler, V. Micó, J. Garcia and Z. Zalevsky, “Linear optics based nanoscopy,” Opt. Exp. 18, 22222-22231 (2010).
21. V. Micó, Z. Zalevsky and J. García, “Edge processing by synthetic aperture superresolution in digital holographic microscopy,” 3D Research, Nov. 2:1 (2011).
22. A. Gur, Z. Zalevsky, V. Micó, J. García and D. Fixler, “The Limitations of Nonlinear Fluorescence Effect in Super Resolution Saturated Structured Illumination Microscopy System,” J. Fluorescence 21, 1075-1082 (2011).

23. A. Calabuig, V. Micó, J. Garcia, Z. Zalevsky and C. Ferreira, “Single-exposure super-resolved interferometric microscopy by RGB-multiplexing,” Opt. Lett. 36, 885-887 (2011
24. L. Granero, Z. Zalevsky and V. Micó, “Single-exposure two-dimensional superresolution imaging in digital holography using a VCSEL source array,” Opt. Lett. 36, 1149-1151 (2011).
25. A. Calabuig, J. Garcia, C. Ferreira, Z. Zalevsky and V. Mico, “Resolution improvement by single-exposure super-resolved interferometric microscopy with a monochrome sensor,” JOSA A 28, 2346-2358 (2011).
26. V. Micó, C. Ferreira, and J. García, "Surpassing digital holography limits by lensless object scanning holography," Opt. Express 20, 9382-9395 (2012).
27. Z. Zalevsky, E. Gur, J. Garcia, V. Micó and B. Javidi, “Superresolved and field of view extended digital holography with particle encoding,” Opt. Lett. 37, 2766-2768 (2012).
28. V. Micó, Z. Zalevsky, and J. García, “Superresolved common-path phase-shifting digital in-line holographic microscopy using a spatial light modulator,” Opt. Lett. 37, 4988-4990 (2012).
29. Z. Zalevsky, L. Chen, S. Gaffling, J. Hutter, W. Iff, A. Tobisch, .J. Garcia, and V. Mico, “Passive Time Multiplexing Super Resolved Technique for Axially Moving Targets,” Appl. Opt. 52, C11-C15 (2013).

- ON QUANTITATIVE PHASE AND 3D IMAGING (Note that some papers included in the optical superresolution topic are also related with quantitative phase imaging due to the holographic nature of the process):

30. J. García, Z. Zalevsky, P. García-Martínez, C. Ferreira, M. Teicher and Y. Beiderman, "3D Mapping and Range Measurement by Means of Projected Speckle Patterns," Appl. Opt. 47, 3032-3040 (2008).
31. Z. Zalevsky, O. Margalit, E. Vexberg, R. Pearl and J. Garcia, "Suppression of phase ambiguity in digital holography by using partial coherence or specimen rotation," Appl. Opt. 47, D154-D163 (2008).
32. V. Mico, Z. Zalevsky and J. Garcia, "Common-path Phase-shifting Digital Holographic Microscopy: a way to Quantitative Phase Imaging and Superresolution," Opt. Commun. 281, 4273-4281 (2008).
33. L. Camacho, V. Mico, Z. Zalevsky and J. Garcia, “Quantitative phase microscopy using defocusing by means of a spatial light modulator,” Opt. Exp. 18, 6755-6766 (2010).
34. V. Mico, E. Valero, Z. Zalevsky and J. Garcia, “Depth sensing using coherence mapping,” Opt. Commun. 283, 3122–3128 (2010).

- ON REMOTE MONITORING OF SOUND (OPTO-PHONE) AND BIOPARAMETERS USING SPECKLE METROLOGY:

35. Z. Zalevsky, Y. Beiderman, I. Margalit, S. Gingold, M. Teicher, V. Mico and J. Garcia, "Simultaneous remote extraction of multiple speech sources and heart beats from secondary speckles pattern," Opt. Express 17, 21566-21580 (2009).
36. Z. Zalevsky, Y. Beiderman, Y. Azani, Y. Cohen, C. Nisankoren, M. Teicher, V. Mico and J. Garcia, "Cleaning and Quality Classification of Optically Recorded Voice Signals," Recent patents on signal processing 2, 6-11 (2010).
37. Y. Beiderman, M. Teicher; J. Garcia, V. Mico and Z. Zalevsky, “Optical technique for classification, recognition and identification of obscured objects,” Opt. Commun. 283, 4274-4282 (2010).
38. Y. Beiderman, A. D. Amsel, Y. Tzadka, D. Fixler, V. Mico, J. Garcia and Z. Zalevsky, “A microscope configuration for nanometer 3-D movement monitoring accuracy,” Micron 42, 366-375 (2011).
39. Y. Beiderman, I. Horovitz, N. Burshtein, M. Teicher, J. Garcia, V. Mico and Z. Zalevsky, “Remote estimation of blood pulse pressure via temporal tracking of reflected secondary speckles pattern,” J. Biomed. Opt. 15, 061707-1, 7 (2010).
40. Y. Beiderman, R. Blumenberg, N. Rabani, M. Teicher, J. Garcia, V. Mico and Z. Zalevsky, “Optical sensor for remote estimation of glucose concentration in blood,” Biomedical Optics Express 2, 858–870 (2011).
41. Y. Beiderman, R. Talyosef, D. Yeori, J. Garcia, V. Mico and Z. Zalevsky, "Use of PC mouse components for continuous measuring of human heartbeat," Appl. Opt. 51, 3323-3328 (2012).
42. D. Cojoc, S. Finaurini, P. Livshits, E. Gur, A. Shapira, V. Mico and Z. Zalevsky, “Toward fast malaria detection by secondary speckle sensing microscopy,” Biomed. Opt. Express 3, 991-1005 (2012).
43. A. Shenhav, Z. Brodie, Y. Beiderman, J. Garcia, V. Mico, and Z. Zalevsky, “Optical sensor for remote estimation of alcohol concentration in blood stream,” Opt. Commun. 289, 149-157 (2012).

- ON LENSLESS MICROSCOPY (Note that some papers included in the optical superresolution topic are also related with lensless microscopy since they are validated without using lenses):

44. Schwarz, A. Weiss, D. Fixler, Z. Zalevsky, V. Micó and J. García, "One-Dimensional Wavelength Multiplexed Microscope without Objective Lens," Opt. Commun. 282, 2780-2786 (2009).
45. V. Micó, J. García, B. Javidi and Z. Zalevsky, "Phase-shifting Gabor Holography," Opt. Lett. 34, 1492-1494 (2009).
46. V. Micó, J. García, Z. Zalevsky, and B. Javidi, “Phase-shifting Gabor holographic microscopy,” IEEE Journal of Display and Technology 6, 484-489 (2010).
47. V. Micó and J. García, "Common-path phase-shifting lensless holographic microscopy," Opt. Lett. 35, 3919-3921 (2010)
48. A. Gur, R. Aharoni, Z. Zalevsky, V. G. Kutchoukov, V. Mico, J. Garcia and Y. Garini, “Sub-Wavelength and Non-Periodic Holes Array based Fully Lensless Imager,” Opt. Commun. 284, 3509-3517 (2011).

- ON POLARIZATION IMAGING AND SLM CHARACTERIZATION

49. J. J. Vallés, P. García-Martínez, and C. Ferreira, "Spherical nonlinear correlations for global invariant three-dimensional object recognition," Appl. Opt. 47, A43-A51 (2008).
50. A. Martínez-García, I. Moreno, M. M. Sánchez-López, and P. García-Martínez, "Operational modes of a ferroelectric LCoS modulator for displaying binary polarization, amplitude, and phase diffraction gratings," Appl. Opt. 48, 2903-2914 (2009).
51. M. M. Sánchez-López, P. García-Martínez, A. Martínez-García and I. Moreno, "Poincaré sphere analysis of a ferroelectric liquid crystal optical modulator: application to optimize the contrast ratio," J. Opt. A: Pure Appl. Opt. 11, 015507 (9pp) (2009).
52. A. Martínez-García, J. L. Martínez, P. García-Martínez, M. M. Sánchez-López, and I. Moreno, "Time-multiplexed chromatic controlled axial diffractive optical elements," Opt. Eng 49, 078201-078208 (2010).
53. P. García-Martínez, J. L. Martínez, M. M. Sánchez-López, and I. Moreno, "Wavelength-compensated time-sequential multiplexed color joint transform correlator," Appl. Opt. 49, 4866-4873 (2010).
54. W. B. Tara, H. H. Arsenault, and P. García-Martínez, "Intensity invariant nonlinear correlation filtering in spatially disjoint noise," Appl. Opt. 49, 4284-4289 (2010).
55. I. Moreno, P. García-Martínez, C. Ferreira, "Teaching stable two-mirror resonators through the fractional Fourier transform" Eur. J. Phys. 31, 273–284 (2010).
56. W. B. Tara, P. García-Martínez, and H. H. Arsenault, "Modified LACIF filtering in background disjoint noise," Opt. Commun. 284, 4430–4434 (2011).
57. J. L. Martínez, P. García-Martínez, M. M. Sánchez-López, and I. Moreno, "Accurate color predictability based on a spectral retardance model of a twisted-nematic liquid-crystal display," Opt. Commun. 284, 2441–2447 (2011).
58. P. García-Martínez, A. Gherabi and H. H. Arsenault, "Image difference detection under varying illumination based on vector space and correlations," Optik 123, 665–669 (2012).
59. J. Albero, P. Garcia-Martinez, N. Bennis, E. Oton, B. Cerrolaza, I. Moreno, and J. A. Davis, "Liquid Crystal Devices for the Reconfigurable Generation of Optical Vortices," J. Lightwave Technol. 30, 3055-3060 (2012).
60. J. L. Martínez, M. M. Sánchez-López, P. García-Martínez, I. Moreno, and J. Campos, "Programmable color tuning of a multiline laser by means of a twisted nematic liquid crystal display," Appl. Opt. 51, 6368-6375 (2012).
61. P. García-Martínez, M. M. Sánchez-López, J. A. Davis, D. M. Cottrell, D. Sand, and I. Moreno, "Generation of Bessel beam arrays through Dammann gratings," Appl. Opt. 51, 1375-1381 (2012).
62. J. Albero, P. Garcia-Martinez, N. Bennis, E. Oton, B. Cerrolaza, I. Moreno, and J. A. Davis, "Liquid Crystal Devices for the Reconfigurable Generation of Optical Vortices," J. Lightwave Technol. 30, 3055-3060 (2012).
63. J. Albero, P. García-Martínez, J. L. Martínez, I. Moreno, "Second order diffractive optical elements in a spatial light modulator with large phase dynamic range," Opt. Laser Eng. 51, 111–115 (2013).

In addition to this list of publications, our group has contributed to 30 conferences (aprox.) in the last 5 years. The list of conference contribution is not listed in this document for saving space.

LIST OF BOOK CHAPTERS:

1. Z. Zalevsky, D. Fixler, V. Mico and J. García, "Nano-Photonics for Bio-Medical Super Resolved Imaging," in Bionanotechnology: Global Prospects, CRC 3rd Ed. Hdbk BioMed Eng (2008).
2. Z. Zalevsky, D. Fixler, J. García and V. Mico, "Holography and Structured Illumination for Super Resolved Imaging," in New Directions in Holography and Speckles, American Scientific Publishers (2008).
3. D. Sylman, Z. Zalevsky, V. Micó and J. García, "Resolution Enhanced Imaging based upon Spatial Depolarization of Light," Springer Book: Information Optics and Photonics, Eds. T. Fournel and B. Javidi (2010).
4. V. Micó, C. Ferreira, Z. Zalevsky and J. García, "Basic principles and applications of digital holographic microscopy" Microscopy Book Series entitled "Microscopy: Science, Technology, Applications and Education" Ed. A. Méndez-Vilas and J. Díaz Álvarez, Formatex Research Center Publisher, Vol. 2, 1411-1418 (Dec. 2010).
5. A. Gur, D. Fixler, V. Micó, J. García and Z. Zalevsky, "Linear versus Non Linear Super Resolved Microscopy" Microscopy Book Series entitled "Microscopy: Science, Technology, Applications and Education," Ed. A. Méndez-Vilas and J. Díaz Álvarez, Formatex Research Center Publisher, Vol. 2, 1426-1435 (Dec. 2010).
6. I. Moreno and C. Ferreira, "Fractional Fourier Transforms and Geometrical Optics," Advances in Imaging and Electron Physics, Elsevier (2010).
7. V. Micó, J. García, L. Camacho and Z. Zalevsky, "Quantitative phase imaging in microscopy using a spatial light modulator," Coherent light microscopy for imaging and quantitative phase analysis, Springer (2011).
8. Y. Beiderman, A. Amsel, Y. Tzadka, D. Fixler, M. Teicher, V. Mico, J. Garcia, B. Javidi and Z. Zalevsky, "Coherent microscopy for nano metric 3-D movement monitoring of cells," Coherent light microscopy for imaging and quantitative phase analysis, Springer (2011).

9. V. Mico, Z. Zalevsky, J. García, M. Teicher, Y. Beiderman, E. Valero, P. García-Martínez and C. Ferreira, “Three-dimensional mapping and ranging of objects using speckle pattern analysis,” Coherent light microscopy for imaging and quantitative phase analysis, Springer (2011).
10. H. Duadi, O. Margalit, V. Mico, J. A. Rodrigo, T. Alieva, J. Garcia and Z. Zalevsky, "Digital holography and phase retrieval," Holography, Research and Technologies, Ch. 20, pp. 407-420, Ed. J. Rosen, InTech Publisher (2011).
11. Z. Zalevsky, A. Schwarz, A. Gur, R. Aharoni, A. Weiss, D. Fixler, Y. Garini, D. Mendlovic, V. Micó, C. Ferreira and J. García, “Usage of Wavelength Multiplexing for Super Resolved Imaging and Spatial Data Compression,” Advances in Communications and Research, Volume 9, Nova publishers (2011).
12. V. Micó, Z. Zalevsky, L. Granero and J. García, “Synthetic aperture digital lensless holographic microscopy for superresolved biological imaging,” Biomedical Optical Phase Microscopy and Nanoscopy, Elsevier (in preparation).
13. A. Zlotnik, Z. Zalevsky, V. Micó, J. García, and B. Javidi, “Super Resolution Methods Implementing Diffractive Masks Having a Certain Degree of Periodicity,” Super-Resolved Imaging - Geometrical and Diffraction Approaches, Springer - New York (2011).
14. A. Zlotnik, Z. Zalevsky, A. Borkowski, D. Sylman, V. Micó, J. García, and B. Javidi, “Techniques Utilizing Diffractive Masks Having Structures with a Period Non-Limited Randomness,” Super-Resolved Imaging - Geometrical and Diffraction Approaches, Springer - New York (2011).
15. J. García, “Optical and Geometrical Superresolution,” Optical and Digital Image Processing - Fundamentals and Applications, Willey (2011).
16. V. Micó, Z. Zalevsky, L. Granero and J. García, “Synthetic aperture lensless digital holographic microscopy for superresolved biological imaging,” Biomedical Optical Phase Microscopy and Nanoscopy, Elsevier (2013).

MAIN PROJECTS AND BRIEF DESCRIPTION:

1. Project Title: BRIGHTLIGHT - Periodic dispersive photonic components for control of spectral, spatial and temporal characteristics of laser diode radiation.
   Financing: European Comission – CRAFT.
   ID: COOP-CT-2006-032482.
   Duration: 2007-2009.
   I.P. (Partner: Univ. Valencia): Javier García Monreal.
   Brief description: Diode lasers are more efficient than any other laser and feature the highest reliability. They are already very strong contenders in the commercial marketplace. Laser diodes are a basic technology for a diversity of applications, such as pumping of solid-state lasers, communications and material processing. At the same time, there are clearly certain deficiencies in their performance that have become critical for many demanding applications e.g. their low spatial and temporal coherence. The consequences of this are a too broad spectral line-width and a poor beam quality. With respect to the spectral range, present laser diode technology (especially for high power) is limited to the near infrared region. Recent advances of GaN technology has resulted in the commercialization of low power (several tens of mW) blue laser diodes around 400 nm. However, large portions of the spectrum are not yet covered by laser diodes. The main aim of this project is the development of low cost, mass production technology for optical components based on volume Bragg gratings in advanced photorefractive materials that control the spatial and temporal coherence of laser diode radiation.
   As a result, a new generation of diode lasers with a very narrow line width and high spatial coherence will be developed and commercialized. As a logical continuation, the second aim is the integration of nonlinear crystals with periodic domain inversion. These will enable the efficient frequency conversion of the high brightness, narrow band laser diode radiation by means of second harmonic generation. This new generation of lasers will find many new applications in different markets. The frequency converted lasers will cover large portions of the spectrum that are not attainable at present by laser diodes. The partners have extensive academic and technological backgrounds in lasers, materials and nonlinear optics. The successful completion of this project will give them a worldwide competitive status.
   The main goal of the partner (Univ. Valencia) leaded by Javier García was the design, characterization, measurement and validation of Bragg gratings for wavelength selection. This involved from optical designs for grating recording in polymer and doped glass to the measurement of the samples produced by other partners.

2. Project Title: Asesoramiento En Sistemas Interferométricos I y II.
   Financing: Instituto Tecnológico de Óptica, Color e Imagen (AIDO).
   Duration: 2008-2009.
   I.P.: Javier García Monreal.
   Brief description: This project was framed in a more complex and general project where the main goal was to obtain a high precision 3D positioning system to be applied to a new type of machine-tool whose control is based in the direct measurement of the tool position. Therefore, the following partial objectives were fulfilled: development of a new tool position measurement system based in optical technology, development of a new machine-tool control system based in the tool position measurement using optical systems, and application of the system to industrial production machines like milling machines and

machining centres. The project activities dealt with the development of the high precision 3D positioning system, the adaptation of the machine-tools, systems' integration and tests and validation.
The goal of the group leaded by Javier García was in the technical guidance of AIDO for the definition, calibration, validation, error measurement, and deviation analysis of the 3D interferometric measurement system to be included in the machine-tool.

3. Project Title: Sistemas ópticos de polarización para procesado de imágenes 2D y 3D (Polarization optical systems for 2D and 3D image processing).
   Financing: Ministerio de Educación y Ciencia, Secretaría de Estado de Universidades e Investigación, Secretaría General de Política Científica y Tecnológica.
   ID: FIS2007-60626.
   Duration: 2008-2010.
   I.P.: Javier García Monreal.
   Brief description: The global aim of this project was the development of optical tools and digital algorithms for the recording, processing and detection of 3D images and range images based on polarization techniques. Inside the project, three main research/working lines were tackled: polarimetric optical correlators, 3D image processing for detection and analysis, and liquid crystal displays for image generation.

4. Project Title: Asesoría para el diseño de sistema de visión artificial para el estudio de la superficie de la madera.
   Financing: ASSEMBLED NEW TECH, S.L.
   Duration: 2008-2009.
   I.P.: Javier García Monreal.
   Brief description: The aim in this Project was to develop an image acquisition and processing system capable of measuring the surface texture of wood under production line.

5. Project Title: Técnicas optoelectrónicas de evaluación y monitorización de diferentes parámetros físicos 'OPTOPAR'.
   Financing: Instituto Tecnológico de Óptica, Color e Imagen (AIDO).
   Duration: 2009.
   I.P.: Javier García Monreal.
   Brief description: Fatigue life of structural materials (such as silicon wafers or photovoltaic solar cells) is broadly classified into two phases: (i) crack initiation and (ii) crack propagation. This classification assumes that the phase transition from crack initiation to crack propagation occurs when several small microcracks coalesce together to develop a single large crack that propagates under oscillating load. But the difficulty is extremely high since microcracks are invisible at a very initial stage. Instrumentation for in-line crack detection is a part of today's standard production lines. However the commercial equipment available today has some serious weaknesses allowing some parts with cracks to pass the inspection. The aim of the project was to develop new solutions for detection of fatigue crack initiation in photovoltaic modules inside the production line.
   The group leaded by Javier García was involved in basic research at the lab stage aimed to develop such new kind of sensing system. In particular, speckle pattern interferometry and quasi-grazing imaging technologies were successfully applied for monitoring vibrations and for detecting crashes in silicon wafers.

6. Project Title: Tecnologías holográfico-difractiva e híbrida aplicadas a diseño de componentes ópticos.
   Financing: Instituto Tecnológico de Óptica, Color e Imagen (AIDO).
   Duration: 2010.
   I.P.: Javier García Monreal.
   Brief description: Solar concentrators using refractive conventional lenses suffer from chromatic aberration which is unfavourable for multijunction solar cells. To enhance solar cell performance and increase the concentrating ratio, one possibility is to use doublets but unfortunately they are too heavy and expensive to be used. Another possibility is provided by hybrid lenses that represent a serious alternative to refractive doublets since they are thiner, lighter and so should be cheaper if made by mass production. Thus, the aim of this research project was to find an alternative to doublets in order to improve - at low cost- the efficiency of solar concentrators. And by alternative technology we mean hybrid (a mix between conventional refractive-reflective with diffractive) as well as holographic technologies.
   The goal of the group leaded by Javier García was in the technical guidance of AIDO for the experimental research in the field of solar concentration by using holographic principles.

7. Project Title: Mejora de la Resolución y Cuantificación en Sistemas de Imagen Coherente (Resolution improvement and quantification in coherent imaging systems).
   Financing: Ministerio de Ciencia e Innovación, Dirección General de Investigación y Gestión del Plan Nacional de I+D+i. ID: FIS2010-16646.
   Duration: 2011-2013.
   I.P.: Javier García Monreal (GPOEI).

Brief description: In this project, several alternative methods aimed to provide quantitative measurement in coherent optical imaging systems with digital recording capabilities are proposed in the following application fields: (a) improvements in the transversal resolution (or superresolution) in digital holographic microscopy (working with or without lenses), (b) quantitative phase imaging in digital holographic microscopy, and (c) movement detection by speckle pattern imaging analysis.
The strategies to be applied for each one of those application fields are, respectively: (a) the use of structured illumination by means of tilted beams (in time sequence or in a single-shot), or by using projected patterns (periodic or random), or by means of static or dynamic physical masks (gratings or randomized masks); (b) common-path interferometric configurations illuminated with partially coherence sources; and (c) speckle pattern image analysis for improvement in temporal resolution and movement measurement (including deformations, tilts, shifts, vibrations, etc) of objects.

BRIEF DESCRIPTION OF PATENTS AND APPLICATIONS:

1. Patent 1. Inventors: A. Shpunt, J. Garcia and Z. Zalevsky, and A. Maziels.
Title: Method and System for Object Reconstruction.
Application Patent number: US 20100177164 A1.
Country: US.
Date of priority: 2006.
Status: Licensed IP. In addition with Patent (1), this patent was made in collaboration with PrimeSense Israeli company. They are part of the patent portfolio that is included in the Kinect device, licensed to Microsoft for Xbox 360.
Brief description: This patent presents a system and method for use in 3D object reconstruction. The system comprises an illuminating unit, and an imaging unit. The illuminating unit comprises a coherent light source and a generator of a random speckle pattern accommodated in the optical path of illuminating light propagating from the light source towards an object, thereby projecting onto the object a coherent random speckle pattern. The imaging unit is configured for detecting a light response of an illuminated region and generating image data. The image data is indicative of the object with the projected speckles pattern and thus indicative of a shift of the pattern in the image of the object relative to a reference image of said pattern. This enables real-time reconstruction of a 3D map of the object.

2. Patent 2. Inventors: Javier Garcia and Zeev Zalevsky.
Title: Range mapping using speckle decorrelation.
Patent number: US 7,433,024 B2.
Country: US.
Date of priority: 2008.
Status: Licensed IP. In addition with Patent (3), this patent was made in collaboration with PrimeSense Israeli company. They are part of the patent portfolio that is included in the Kinect device, licensed to Microsoft for Xbox 360.
Brief description: This patent describes a method for 3D mapping that includes projecting a set of primary speckle pattern dots from an illumination assembly into a target region (3D volume). Then, a plurality of reference images of the primary speckle pattern are captured at different respective distances from the illumination assembly in the target region. The test image of the primary speckle pattern dots that are projected onto a surface of a 3D object in the target region is captured and compared to the reference images so as to identify a reference image in which the primary speckle patterns most closely matches the primary speckle patterns in the test image. As consequence, the location of the object is estimated based on a distance of the identified reference image from the illumination assembly.

3. Patent 3. Inventors: Zeev Zalevsky and Javier Garcia.
Title: Motion detection system and method
Israeli Patent Application No. 184868 (July 2007); WO/2009/013738
International Application No PCT/IL2008/001008 (July 2008).
Status: Licensed IP. Has been licensed for far east countries in Homeland Security applications through a contract held by Bar Ilan University and University of Valencia. The amount of the license exceeds 1 M$.
Brief description: The ability of dynamic extraction of remote sounds is very appealing. In this patent, an optical approach allowing the extraction and the separation of remote sound sources is presented. The approach is very modular and it does not apply any constraints regarding the relative position of the sound sources and the detection device. The optical setup doing the detection is very simple and versatile. The principle is to observe the movement of the secondary speckle patterns that are generated on top of the target when it is illuminated by a spot of laser beam. Proper adaption of the imaging optics allows following the temporal trajectories of those speckles and extracting the sound signals out of the processed trajectory. Various sound sources are imaged in different spatial pixels and thus blind source separation becomes a very simple task.

4. US Patent application 1: Inventors: Javier García and Alexander Shpunt.
Title: Depth ranging with Moiré patterns.
US Application Number: 20100201811.

Publication date: 12-August-2010.
Brief description: In this application, a method for 3D mapping of an object, including projecting with a projector a set of fringes on the object and capturing an image of the object in a camera, is patented. The method further includes processing the captured image so as to detect a Moiré pattern associated with the object and so as to extract depth information from the Moiré pattern, and configuring the projector and the camera so that a locally unambiguous characteristic of the Moiré pattern is related to a depth of the object.

5. US Patent application 2: Inventors: Zeev Zalevsky, Yevgeny Beiderman, Javier Garcia, and Vicente Mico.
Title: Optical Sensor for Remote Estimation of Glucose Concentration in Blood.
US Application Number: 61/457,202.
Filing date: 28-Jan-2011.
Brief description: This patent describes the application of the previously presented technology (see Patent 3 of the present list) and its capability to monitor glucose concentration in blood stream. The technique is based on the tracking of temporal changes of reflected secondary speckle produced in human skin (wrist) when being illuminated by a laser beam. A temporal change in skin's vibration profile generated due to blood pulsation is analyzed for estimating the glucose concentration.

6. US Patent application 3: Inventors: Zeev Zalevsky, Javier Garcia, Vicente Micó, Michael Belkin, Yevgeny Beiderman, Israel Margalit, and Revital Barelly.
Title: Method and system for non-invasively monitoring biological or biochemical parameters of individual.
US Application Number: PCT/IL2012/050029.
Filing date: 02-August-2012.
Status: Licensed IP. This patent application is the base for a contract for developing and licensing the technology for biomedical applications by a multinational company. The contract exceeds the 3M$ amount.
Brief description: This application covers a system and method aimed to monitoring one or more conditions of a subject's body. The system comprises a control unit which comprises an input port for receiving image data, a memory utility, and a processor utility. The image data is indicative of data measured by a pixel detector array and is in the form of a sequence of speckle patterns generated by a portion of the subject's body in response to illumination thereof by coherent light according to a certain sampling time pattern. The memory utility stores one or more predetermined models, the model comprising data indicative of a relation between one or more measurable parameters and one or more conditions of the subject's body. The processor utility is configured and operable for carrying out the following: processing the image data and determining a spatial correlation function between successive speckle patterns in the sequence, and determining a time varying spatial correlation function in the form of a time-varying function of at least one feature of the correlation function, the time-varying spatial correlation function being indicative of a change of the speckle pattern over time; selecting at least one parameter of the time-varying spatial correlation function, and applying to said at least one parameter one or more of the models to determine one or more corresponding body conditions; and generating output data indicative of said one or more corresponding body conditions.

7. European Patent application 4: Inventors: Javier Garcia Monreal, Vicente Mico Serrano, Ian Wallhead, Jose Vicente García Ortíz, Jose Ignacio González Toledo, and Cristóbal González Toledo.
Title: Multi-order diffractive optical element for concentration of broadband electromagnetic radiation.
European Application Number: 12188757.4-2217.
Filing date: 17-Oct-2012.
Brief description: This patent application describes an optical element for collecting broadband electromagnetic radiation and that includes an input face and an output face. The first input face receives electromagnetic radiation of many wavelengths consistent with a broadband spectrum such as the sun. At the second output surface the light exits the optical element in the direction towards a focus where the electromagnetic energy is received by a receiver. One or both of the first input and second output surfaces incorporates a multi-order diffractive component which contributes in whole or in part to the deviation of light rays from their incident direction toward the region of the focus of the optical element.

LIST OF THESIS AND MASTER THESIS:

THESIS:

- JOSÉ JAVIER VALLÉS VILAR. Thesis title: “Correlaciones invariantes de objetos tridimensionales”, Data: May-2009, PhD Advisors: Carlos Ferreira, Pascuala García-Martínez and Javier García.
- VICENTE MICÓ SERRANO. Thesis title: “Experimental research on superresolution imaging by synthetic aperture generation”, Data: September-2009, PhD Advisors: Javier García and Zeev Zalevsky.

MASTER THESIS:

- Luis Granero Montagud.
- Luis Camacho Torrente. Master: Física Avanzada, Master Thesis Title: “Imagen cuantitativa de fase en microscopía no holográfica usando un modulador espacial de luz”. Date: June-2010. Supervisor: Vicente Micó Serrano.
- Beatriz Perucho Flechoso. Máster: Optometría avanzada y ciencias de la visión, Master Thesis Title: “Estudio comparativo entre la agudeza visual monocular en tareas de reconocimiento y de resolución. Aplicación a alta miopía”. Date: June-2010. Supervisor: Vicente Micó Serrano.
- Alejandro Calabuig Barroso. Master: Física Avanzada, Master Thesis Title: “Microscopía interferométrica superresolvente unidimensional de única exposición [SESRIM] mediante multiplexado en RGB”. Date: September-2011. Supervisor: Vicente Micó Serrano.
- Javier Martínez Barra. Máster: Optometría avanzada y ciencias de la visión, Master Thesis Title: “Revisión de técnicas de observación del endotelio corneal. Mircoscopía holográfica digital”. Date: September-2011. Supervisor: Vicente Micó Serrano.
- Paula Bernal Molina. Máster: Optometría avanzada y ciencias de la visión, Master Thesis Title: “Profundidad de campo del ojo humano durante la acomodación”. Date: June-2012. Supervisors: Norberto López Gil and Vicente Micó Serrano.