



PM²⁰¹⁸ Photo
Mechanics

MARCH 20-22, 2018
Toulouse, France

6th International conference on
full-field measurement techniques
and their applications in
experimental solid mechanics

Program

organised by:



Program of

PhotoMechanics 2018

International conference on full-field measurement techniques
and their applications in experimental solid mechanics

19–23 March 2018, Toulouse, France

Conference **Chairs**

Jean-Charles Passieux, INSA Toulouse, ICA, jean-charles.passieux@insa-toulouse.fr

Jean-Noël Périé, IUT Toulouse 3, ICA, jean-noel.perie@iut-tlse3.fr

Jean-José Orteu, IMT Mines Albi, ICA, jean-jose.orteu@mines-albi.fr

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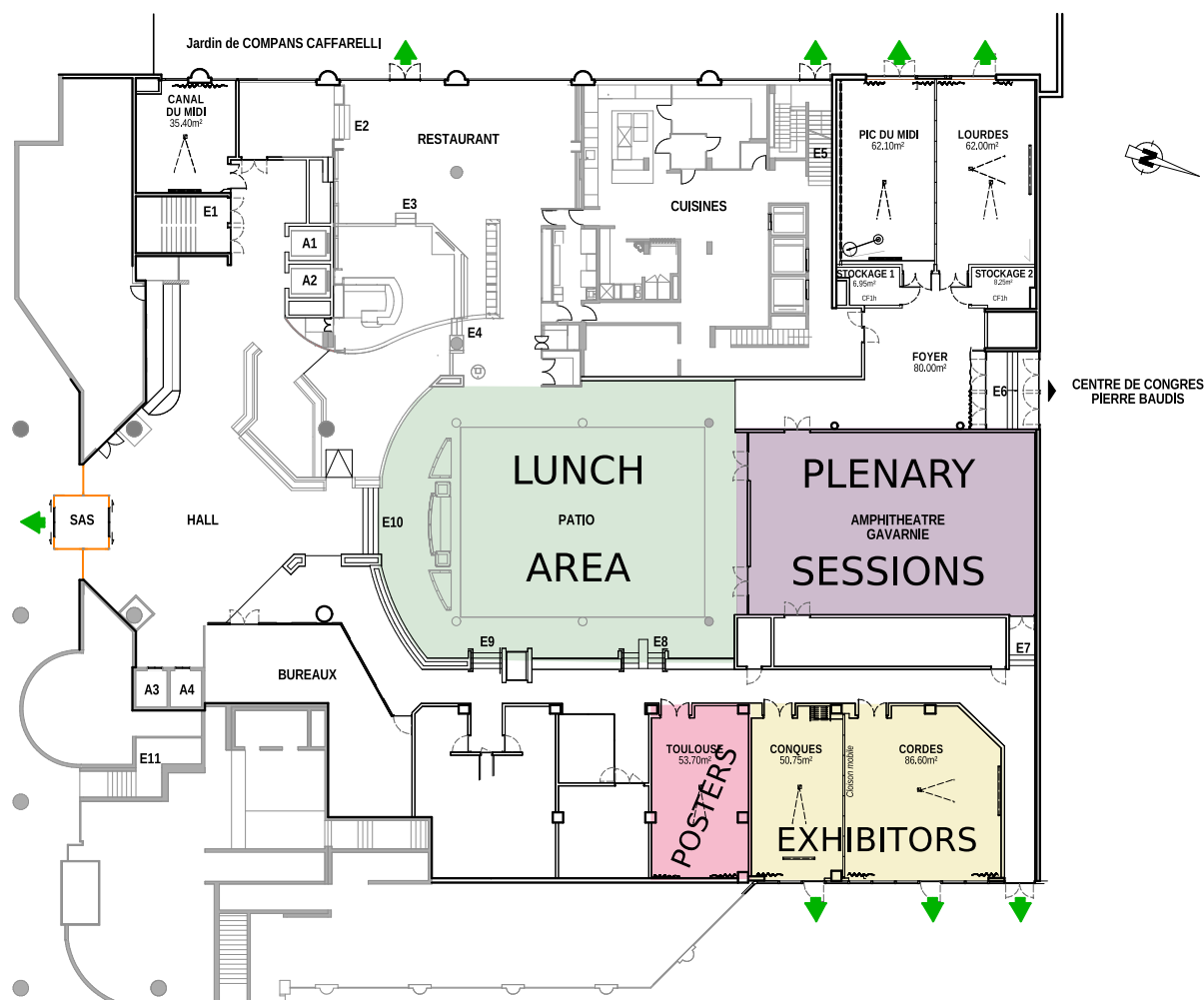
B. Wattrisse, France

H. Xie, China

Conference Venue Map

Hôtel Mercure Toulouse Centre Compans

Boulevard Lascrosses, 8 Espl. Compans Caffarelli, 31000 Toulouse



Toulouse, south western France

Nicknamed 'La Ville Rose' (the Pink City) on account of the terracotta bricks used in many of its buildings, Toulouse is France's fourth-largest urban area. The site of a human settlement since at least as far back as the eighth century BC, Toulouse has embraced the technological age in recent years, becoming the capital of the European aeronautics industry and boasting the continent's largest space centre, as well as a vibrant university population. At the same time it remains steeped in history and can claim to be one of France's most enchanting destinations, having often been voted the most desirable place in the country to live. Highlights include the medieval old town, the elegant Capitole building and the Canal du Midi, which links the Garonne river to the Mediterranean Sea. Cassoulet enjoys pride of place among the local culinary specialities.

More information about Toulouse: <http://www.toulouse-visit.com/>

Social program

- Tuesday afternoon, **Downtown visit**



Discover an exceptional heritage! Experience the city's history through our great monuments (amphitheatres, churches, cathedral, basilica and river banks). Toulouse has a small center, and you can reach most interesting places in the downtown area comfortably on foot. The visit is escorted by licensed tour guide lecturers. The visit will be dedicated to history, monuments and heritage as well as to some more unusual sights of the city.

Start: 17:30, Mercure Hotel — **End:** 19h30

Transport: by foot

- Wednesday evening, **Museum & Banquet**



An important historical resource forging strong links between the past, present and future of the aviation world, aeroscopia's aim is not only to preserve and optimise the presentation of unique items provided by local heritage organisations and Airbus Operations SAS, but also to pass on aeronautical culture – a fundamental building block in the construction of the region's identity.

Start: 18:30, Mercure Hotel — **End:** around midnight

Transport: by chartered bus

- Friday morning, **AIRBUS Assembly Line** (optional)



The J.L. Lagardère site is entirely dedicated to final assembly and flight preparations of the A380. It occupies an area of 50 hectares, including a 10-hectare assembly hall. The Airbus Discovery tour will reveal all the secrets of the world's only true double-decker, from the design stage through to the commercial service and will enable you to board the emblematic military aircraft of Airbus the A400M to find out all there is to know about military aviation and transport.

Start: 08:30 (to be confirmed), Mercure Hotel

Visit: between 10:00 and 11:30

Stop 1: (way back) around 12:00 at the Airport

Stop 2: (way back) around 12:30 at Mercure Hotel

Transport: by chartered bus

Week Program at a glance

MONDAY, 19th	TUESDAY, 20th	WEDNESDAY, 21st	THURSDAY, 22nd
	08:00 REGISTRATION		
	08:50 OPENING	8:30 Keynote Lecture S. Avril	08:30 Keynote Lecture B. Pan
09:00 Course on DIGITAL IMAGE CORRELATION M. Bornert	09:10 Keynote Lecture E. Whitemont	09:15 SESSIONS	
COFFEE BREAK	09:55 SESSIONS	EXHIBITOR PITCHES	09:15 SESSIONS
10:50 Course on IR THERMOGRAPHY FOR THERMO-MECHANICS B. Wattrisse	COFFEE BREAK & EXHIBITORS & POSTERS	EXHIBITOR PITCHES	COFFEE BREAK & EXHIBITORS & POSTERS
	11:25 SESSIONS	11:25 SESSIONS	
	POSTER PITCHES	POSTER PITCHES	11:25 SESSIONS
	EXHIBITOR PITCHES	EXHIBITOR PITCHES	
LUNCH	LUNCH	LUNCH	LUNCH
13:50 Course on IDENTIFICATION M. Bonnet	14:00 SESSIONS	14:00 SESSIONS	
COFFEE BREAK	POSTER PITCHES	POSTER PITCHES	14:00 SESSIONS
15:40 Course on UNCERTAINTIES IN IDENTIFICATION & MEASUREMENTS S. Roux	COFFEE BREAK & EXHIBITORS & POSTERS	COFFEE BREAK & EXHIBITORS & POSTERS	
	16:00 SESSIONS	16:00 SESSIONS	CLOSING SESSION & BEST YOUNG INVESTIGATOR PRIZE & FAREWELL DRINK
	EXHIBITOR PITCHES	POSTER PITCHES	
18:00 WELCOME DRINK & REGISTRATION	17:30 DOWNTOWN VISIT		
FREE EVENING	FREE EVENING	18:30 AEROSCOPIA MUSEUM VISIT & CONFERENCE BANQUET	FRIDAY, 23rd
			10:00 AIRBUS ASSEMBLY LINE VISIT

Tuesday, **March 20**

08:30 *Registration*

08:50 *Opening Session*

Keynote Lecture 1

chair: A. Chrysochoos

09:10 Imaging of material deformation processes — Examples of thermal-, visible-, combined- and hyper-spectrum image streams blended with scalar data streams
E. Whitemton

Session

chair: B. Wattrisse

09:55 Rapid assessments of heat source fields using a POD preprocessing of quantitative infrared images
A. Chrysochoos and A. Benaarbia

10:15 Locating cracks in bolted double-lap joints using thermoelastic stress analysis
C. A. Middleton, A. Gaio, R. J. Greene and E. A. Patterson

10:35 Temperature compensation in photomechanics
S. Zhou, Q. Ma, H. Zhu and S. Ma

10:55 Coffee break – Exhibitors – Posters

Session

chair: E. Whitemton

11:25 Proposition of a Terahertz thermometry system to measure temperature in the thickness of a solid polymer
C. Poulin, M. Triki, K. Bousmaki, A. Duhant, H. Louche and B. Wattrisse

11:45 Multimodal setups for the study of fresh Zircaloy-4 claddings under simulated thermal-mechanical RIA conditions
T. Jailin, N. Tardif, J. Desquines, M. Coret, T. Breville, P. Chaudet, M.-C. Bailetto, V. Georghum and C. Bernaudat

12:05 Experimental investigation of thermal field obtained by near infrared thermography (pitch)
C. Zhang, J. Marty, A. Maynadier, P. Chaudet, J. Réthoré and M.C. Bailetto

12:10 Fatigue analysis of a 3D-printed maraging steel by infrared thermography (pitch)
C. Douellou, X. Balandraud and E. Duc

12:15 A micro-scale coupled measurement of temperature and kinematic fields in Ti6Al4V serrated chip formation
M. Harzallah, T. Pottier, R. Gilblas, Y. Landon, M. Mousseigne and J. Senatore

12:35 Optimization of thermal joint behaviour for the detection of bonding defects by infrared thermography
M. Barus, H. Weleman, V. Nassiet, M.L. Pastor, A. Cantarel, F. Collombet, L. Crouzeix and J.C. Batsale

12:55 Presentation of TELOPS – **P. Lagueux, S. Boubanga**

13:00 Presentation of WAVETEL – **A. Bout**

13:05 Lunch

Session	chair: F. Amiot
14:00	High temperature grain boundary sliding in metallic materials: SEM in situ experimental investigations and characterization by DIC A. El Sabbagh, A. Dimanov, J. Raphanel and M. Bornert
14:20	Dense packing of highly deformed grains: local strain measurement J. Barés, T. L. Vu and S. Mora
14:40 (pitch)	Evaluation of the tow buckling defect by focus variation microscopy and digital image correlation in relation to the complex preforming of flax based woven fabrics M.M. Salem, M. Fazzini, E. De Luycker and P. Ouagne
14:45	Sub-grain scale elastic and plastic deformations in polycrystalline metallic alloys assessed via digital image correlation techniques J.-C. Stinville, D. Texier, N. Vanderesse, F. Bridier, J. Liu, P. Bocher, M.P. Echlin, P.G. Callahan and T.M. Pollock
15:05	In-situ Surface Reconstruction and Image Correlation for Scanning Electron Microscopy J. Neggers, S. Roux

15:30 Coffee break – Exhibitors – Posters

Session	chair: P. Feissel
16:00	On Micromechanical Parameter Identification and the Role of Kinematic Boundary Conditions O. Rokoš, J.P.M Hoefnagels, R.H.J. Peerlings, and M.G.D. Geers
16:20	Single crystal plasticity parameters identification from residual imprint topography after nano-indentation E. Renner, Y. Gaillard, F. Richard, P. Delobelle and F. Amiot
16:40	Presentation of DIMIONE Systems – M. Chiani
16:45	Presentation of 3DMAGINATION – K. Madi
16:50	Synthetic speckle rendering with a Boolean model F. Sur, B. Blaysat, M. Grédiac

17:30 Start of the Downtown visit

Wednesday, **March 21**

Keynote Lecture 2

chair: M. Coret

08:30	Identification of regional, nonlinear and anisotropic material properties in soft tissue biomechanics using 2D and 3D full-field measurements S. Avril
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Session

chair: S. Avril

09:15	In vitro optical measurements of the thickness variations and stress and rupture analysis of ascending thoracic aneurysms C. Cavinato, J. Molimard, N. Curt, S. Campisi and P. Badel
09:35	Integrated DVC approach applied to augmented vertebral bodies K. Madi, G. Tozzi, L. Courtois, J. Hummel and F. Hild
09:55	Presentation of EikoSim – R. Gras
10:00	Presentation of MatchID – M. Sabbe
10:05	Full-field large deformation measurement on custom made craniofacial prostheses obtained through Superplastic Forming K. Genovese, D. Sorgente, A. Piccininni and G. Palumbo
10:25	Mueller matrix microscopic polarimeter for mechanical properties of bio-samples Y. Otani and T. Horiguchi
10:45	Presentation of Dantec Dynamics – T. Siebert

10:50 Coffee break – Exhibitors – Posters

Session

chair: J.N. Périé

11:25	Coupling thermal and kinematic full field measurement for the mechanical characterization of metals at high temperature R. Bonnaire, B. Verdeil, R. Gilblas, Y. Le Maoult and T. Sentenac
11:45	Multi-instrumentation of very high temperature tests T. Archer, P. Beauchêne, C. Huchette, M. Berny, F. Hild, T. Vandellos and B. Lacombe
12:05 (pitch)	On performing stereocorrelation at very high temperatures M. Berny, T. Archer, F. Hild, V. Herb and B. Lacombe
12:10 (pitch)	Thermography inspired data processing methods applied to shearography for improved defect detection. P. Blain, M. Kirkove, G. Baranger, J.-F. Vandenrijt, F. Languy, L. Clermont and M. Georges
12:15	Strain fields measurement during $\alpha - \gamma$ transformation in Armco iron N. Bruzy, M. Coret, B. Huneau, E. Bertrand, G. Kermouche and M. Mondon
12:35	Coupling acoustic and full-field measurements to study austenite- martensite avalanches in a shape-memory alloy X. Balandraud, B. Blaysat, M. Grédiac, E. Vives and G. Zanzotto
12:55	Presentation of Kilonewton / CSI – J. Relland, L. Pilot, H. Schreier
13:00	Presentation of Holo3 – S. Jaminion

13:05 Lunch

Session

chair: J.C. Passieux

14:00 Digital image correlation for displacement measure on boundaries
M. Baconnais, M. François and J. Réthoré

14:20 Determination of Camera Parameters of Conical Calibration Targets
C.-H. Hwang, W.-C. Wang and Y.-S. Chen

14:40 Inverse identification of the loading applied by a tire on an aircraft wheel for an inflation case
(pitch)
K. Cosseron, R. Gras, D. Mellé, J.-F. Diebold, F. Hild and S. Roux

14:45 Towards a multiscale identification strategy based on the modified constitutive relation error
(pitch)
S. Huang, P. Feissel and P. Villon

14:50 Hierarchical refinement of Isogeometric Stereo-DIC
P. Van Zuijlen, J.-E. Dufour and C. Verhoosel

15:10 Thermomechanical field measurements by hybrid stereocorrelation
Y. Wang, A. Charbal, F. Hild, S. Roux and L. Vincent

15:30 Coffee break – Exhibitors – Posters

Session

chair: E. Patterson

16:00 Structural intensity assessment on shells
F. Pires, P. G. G. Muyschondt, W. Keustermans, S. Vanlanduit and J. J. J. Dirckx

16:20 Dynamic behavior of a civil engineering beam
X. Régal, G. Cumunel, M. Bornert and M. Quiertant

16:40 A PGD variable separation approach for the time regularization of digital image correlation.
(pitch)
R. Bouclier, J.-C. Passieux and J.-N. Périé

16:45 Dedicated global DIC to study the global behavior of a workpiece during its milling
(pitch)
G. Rebergue, B. Blaysat, H. Chanal and E. Duc

16:50 High-Resolution cisoids extraction from full-field measurements applied to structural characterization
P. Margerit, A. Lebéé and J.F. Caron

17:10 THz ptychography and digital holography: a comparison
E. Hack, L. Valzania, P. Zolliker and T. Feurer

17:30 Advanced digital volume correlation for large non-uniform deformation measurement of high-resolution volume images
B. Pan and B. Wang

18:30 Bus transfert to Aeroscopia Museum – Visit of the Museum – Conference Banquet

23:00 Bus transfert back to Mercure Hotel

Thursday, **March 22**

Keynote Lecture 3

chair: S. Roux

08:30	Towards High-Accuracy Digital Image/Volume Correlation Measurements: A Perspective From Imaging B. Pan
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Session

chair: J. Réthoré

09:15	A new crack path tracking methodology based on dense displacement field estimation S. Feld-Payet, G. Le Besnerais, D. Pacou and V. Bonnard
09:35	Full field measurements during dynamic crack crack growth in elastomer T. Corre, M. Coret, E. Verron, B. Leblé and F. Le Lay
09:55	Crack characterization from DVC with low intrusiveness A. Bouterf, S. Roux and F. Hild
10:15	Damage and crack monitoring of high temperature fatigue loaded textile composites: 2D-DIC and 3D μ CT comparison. F. Foti, Y. Pannier, D. Mellier and M. Gigliotti
10:35	In-situ bending behavior and failure characterization of 3D needle-punched C/SiC composite Y.L. Dong, X.L. Shi, Z.Y. Zhang and B. Pan

10:55 Coffee break – Exhibitors – Posters

Session

chair: M. Grédiac

11:25	In-plane shear behaviour of masonry wall under constant normal load – Experimental investigation and discrete element modelling V. Venzal, V. Huon, T. Parent, F. Dubois, S. Morel and B. Wattrisse
11:45	Evaluation of a full-field measurement method used to identify the dynamic fracture energy of concrete based on simulated experiments B. Lukić, D. Saletti, P. Forquin
12:05	Experimental characterization of cover-plate steel bolted joints E. Cavene, E. Toussaint, S. Durif and A. Bouchair
12:25	Characterizing the local behavior of asphalt pavements with the grid method M. C. Teguedy, B. Blaysat, E. Toussaint, S. Moreira, S. Liandrat, M. Grédiac
12:45	Radiography-based mechanical identification C. Jailin, A. Buljac, A. Bouterf, F. Hild and S. Roux

13:05 Lunch

Session	chair: M. Bornert
14:00	A cyclic plasticity study by coupling Digital Image Correlation and Finite Elements methods J. Hosdez, M. Langlois, J-F. Witz, N.Limodin, D. Najjar and E. Charkaluk
14:20	Identification of heterogeneous elasto-plastic behaviors using the Constitutive Equation Gap Method T. Madani, Y. Monerie, S. Pagano, C. Pelissou and B. Wattrisse
14:40	What's the probability that a simulation agrees with your experiment? K. Dvurecenska, E. Patelli and E. A. Patterson
15:00	From big data to key data S. Roux, C. Jailin, J. Neggers, F. Hild and O. Allix
15:20	Non-parametric evaluation of stress fields from digital images J. Réthoré, A. Leygue, L. Stainier, M. Coret and E. Verron
15:40	Closing Session – Best Young Investigator Prize
15:50	Farewell Drink

Friday, **March 23**

10:00	Optional Visit of AIRBUS Final Assembly Line
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Additional **Posters**

Measurement on the elastic constants of a circular CFRP plate by bending test B. Guo, W. Liu, Q. Liu and P. Chen
A driven wedge test monitored by DIC to characterize adhesion of a nanostructured-functionally graded epoxy adhesive joint M. Fazzini, O. Tramis, B. Hassoune-Rhabbour and V. Nassiet
Accurate, real-time and remote bridge deflection measurement using video deflectometer with drift correction L. Tian and B. Pan

List of **Exhibitors**

3Dmagination — K. Madi
Dantex Dynamics — T. Siebert
Dimione Systems — M. Chiani
EikoSim — R. Gras
Hirox Europe — H. Le Golvan
Holo3 — S. Jaminion

KiloNewton/CSI — J. Relland, L. Pilot, H. Schreier
MatchID — M. Sabbe
Photron — T. Nicholls
Telops — P. Lagueux, S. Boubanga
Wavetel — A. Bout

Keynote speaker:
Stéphane Avril, France



avril@emse.fr

Identification of regional, nonlinear and anisotropic material properties in soft tissue biomechanics using 2D and 3D full-field measurements

Abstract : Histopathological changes that occur in diseased soft tissues manifest at the macroscopic level as altered mechanical functionality and structural integrity. Correlations between local tissue composition and mechanical properties can thus provide increased insight into conditions that render a soft tissue susceptible to failure or disease. Toward this end, we have used the virtual fields method to determine locally varying values of constitutive parameters from a set of full-field data acquired during tension-inflation tests of arteries using a combination of panoramic digital image correlation (p-DIC) and of optical coherence tomography - digital volume correlation (OCT-DVC). The approach has permitted to reveal for the first time the local material heterogeneities of aortic aneurysms and to relate them to the biological dysfunctions that render blood vessels susceptible to potential rupture.

Bio: Stéphane Avril is Full Professor at Institut Mines Telecom with affiliations at Mines Saint-Etienne and University of Lyon in France. He runs a group of 20+ in soft tissue biomechanics, with a special focus on constitutive modeling and identification using imaging techniques. He is also director of the CIS center for biomedical and healthcare engineering (65+ people) and deputy director of SAINBIOSE (INSERM endorsed laboratory with 100+ researchers). Stéphane received his PhD in mechanical and civil engineering in 2002 at Mines Saint-Etienne (France). After positions at Arts et Métiers ParisTech (France) and Loughborough University (UK) where he developed the Virtual Fields Methods, Stéphane returned to his alma mater in 2008 and extended his broad experience of inverse problems to soft tissue biomechanics, especially regarding aortic aneurysms in close collaboration with vascular surgeons. Stéphane was a visiting Professor at the University of Michigan Ann Arbor (USA) in 2008 and has been a visiting professor at Yale University since 2014. In 2015, Stéphane was awarded an ERC (European Research Council) consolidator grant of 2m€ for the Biolochanics project on: Localization in biomechanics and mechanobiology of aneurysms: Towards personalized medicine.

Keynote speaker:
Bing Pan, China



panb@buaa.edu.cn

Towards High-Accuracy Digital Image/Volume Correlation Measurements : A Perspective From Imaging

Abstract: In the experimental mechanics community, digital image/volume correlation (DIC/DVC) techniques have been widely accepted as the most popular, practical and versatile tool for full-field surface/internal displacement and deformation measurements. Basically, the implementation of DIC/DVC measurements involves two consecutive stages: namely image acquisition and image processing. At present, the state-of-the-art DIC/DVC algorithms using inverse compositional Gauss-Newton (IC-GN) algorithm and B-spline interpolation scheme allow subpixel/subvoxel registration with an accuracy higher than 0.005 pixels/voxels for computer simulated speckle pattern. However, for real experimental images recorded by common imaging systems, the accuracy of DIC/DVC measurements can be seriously degraded. Since measurement accuracy is always the most important objective in various experimental mechanics applications, the errors associated with image acquisition must be understood, quantified and minimized. In this talk, we will first point out that all the common imaging systems (e.g. a single camera for 2D-DIC, synchronized two cameras for stereo-DIC, or a x-ray CT scanner for DVC) are neither perfect nor stable, because of the existence of lens distortion and the continual slight changes in imaging geometry associated with the self-heating effect or ambient temperature variations. Then, we systematically investigate the measurement errors in 2D-DIC, stereo-DIC and DVC from the perspective of the stability of image acquisition devices. Our experimental results show that the maximum temperature-induced artificial strains can reach an magnitude of 200, 150, and 400 microstrains for the specific imaging devices used by the authors. Finally, we discuss several approaches that can be used to mitigate or correct these errors. In particular, we focus on an easy-to-implement but effective reference specimen compensation method, and validate its efficacy and practicality by real experiments.

Bio: Dr. Bing Pan is a full professor in School of Aerospace Science & Engineering at Beihang University (BUAA), China. He received his Ph.D degree in Mechanical Engineering from Tsinghua University in 2008. After working with Professor Anand Asundi in Nanyang Technological University (Singapore) as a postdoctor, he joined Institute of Solid Mechanics, BUAA in 2009. His current research interests mainly focus on advanced optical techniques and their applications in experimental mechanics, especially the digital image correlation, digital volume correlation techniques for surface or internal deformation measurement of solid materials and structures, as well as new experimental techniques for characterizing thermo-mechanical behavior of hypersonic materials and structures. He has published more than 80 peer-reviewed articles in international journals, and six of these papers were selected as ESI highly cited papers. All his publications have been cited more than 2600 times according to Web of Science and more than 4800 times according to Google Scholar. Dr. Pan was selected for Youth Changjiang Scholars (MOE) in 2016, and won the National Natural Science Funds for Excellent Young Scholar in 2013.

Keynote speaker:

Eric Whinton, United States of America



Eric.Whinton@Nist.Gov

Imaging of material deformation processes – Examples of thermal-, visible-, combined- and hyper-spectrum image streams blended with scalar data streams.

Abstract: Thermal imaging is used to study material deformation processes such as machining. However, determining uncertainty for measured temperatures must take many factors into consideration. Combining traditional, single wavelength thermal imaging with other measured image and scalar data can significantly improve temperature measurements. For example, when using mid wave infrared cameras, the relatively long wavelength of light cause high magnification images to appear somewhat blurry. For situations where the material is rapidly moving, it is sometimes difficult to know exactly what is being imaged. Without knowing the speed of imaged objects, effects such as motion blur are difficult to account for. Combining thermal spectrum images with visible spectrum images can resolve these issues due to the shorter wavelength of visible light, coupled with the fact that visible cameras can often use shorter integration times than thermal cameras. Another example is when emissivity is unknown or rapidly changing. The additional information provided by imaging multiple wavelengths can help by providing estimates of emissivity. Also, image and scalar data streams may be blended. Examples include when embedded thermocouple data is compared to imaged temperatures. This talk will discuss using single and multiple data stream approaches in several research activities at the National Institute of Standards and Technology. These include situations such as metal cutting, a rapidly heated Split-Hopkinson bar, determining fiber orientation angle effects in machining of unidirectional CFRP laminated composites, metal powder-bed additive manufacturing, and others.

Bio: In 1980, Mr Eric Whinton started at the National Institute of Standards and Technology (NIST) in the American Dental Association facility. He subsequently moved to the Tribology Group, and then the Precision Machining Research Facility Group. He is currently a guest researcher in the Production Systems Group. For the past 15 years, he has been using visible and thermal spectrum imaging to better understand high-speed deformation processes, primarily of metals. Previous activities include macro scale, high speed, dual spectrum imaging where thermal and visible spectrum images are simultaneously acquired through a shared lens, as well as uncertainty estimation for traditional thermal spectrum imaging. Current activities include using hyperspectral thermal imaging to measure temperatures, and using joint time-frequency analysis of inexpensive infrared spectrum sensors for improved understanding of metal powder-bed additive machining.

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