Scientific Report


I. LIST OF PUBLICATIONS

A. Books


B. Chapters in Books


C. ISI Journal Papers


D. Conference Proceedings


II. PERFORMANCE CRITERIA AND RESEARCH IMPACT

Taking into account that in the period January – December 2012 eight papers were published, accepted for publication in or submitted to ISI journals, i.e.

- 1 paper has been published in an ISI journal [3];
- 5 papers have been accepted for publication in ISI journals [4-8];
- 2 papers have been submitted to ISI journals [9, 10];

we consider that all of the required performance criteria have been fulfilled. According to *Journal Citation Reports 2012*, published by *Thomson Reuters*, the cumulative IF corresponding to the aforementioned papers is 10.023.

**Mobilities** have received a special attention since they are essential for the dissemination of the results, as well as continuing the ongoing and developing new international collaboration with world leading scientist in the field of theoretical and computational mechanics and inverse problems. More precisely

1. Dr. Liviu Marin attended the following international conferences:
   a. *Sixth International Conference “Inverse Problems: Modeling & Simulation”,* Turcia (invited talk);
   b. *Boundary Elements and other Mesh Reduction Methods XXXIV (BEM/MRM 2012)*, Croaţia;
   c. *International Conference on Boundary Element and Meshless Techniques XIII*, Republica Cehă (membru în Comitetul Științific al Conferinței; chairman al unei sesiuni de comunicari).

   Also, Dr. Liviu Marin made a research visit at Oxford Brookes University, Oxford, UK, 20-25 November 2012, invited by Dr. Cristiana Sebu.

2. Prof. Dr. Sanda Cleja-Ţigoiu made a research visit at the University of Aix-Marseille, France, in the period 3-15 September 2012, invited by Prof. Marius Cocou.
3. Dr. Ionel-Dumitrel Ghiba made a research visit at the University of Duisburg-Essen, Germany, 27 August - 29 September 2012, invited by Prof. Patrizio Neff.

4. Prof. Andreas Karageorghis (Universitatea din Cipru) will make a research visit at the Institute of Solid Mechanics, Romanian Academy, in the period 4-8 December 2012, invited by Dr. Liviu Marin.

III. DESCRIPTION OF THE RESULTS OBTAINED

Rezultatele obținute în perioada decursului anului 2012 se pot împărți în următoarele clase majore:

a. Direct Problems in Two-Dimensional Linear Thermoelasticity

In papers [9, 12], we consider the numerical approximation of the boundary and internal thermoelastic fields in the case of two-dimensional isotropic linear thermoelastic solids by combining the method of fundamental solutions (MFS) with the method of particular solutions (MPS). A particular solution of the non-homogeneous equations of equilibrium associated with a planar isotropic linear thermoelastic material is derived from the MFS approximation of the boundary value problem for the heat conduction equation. Moreover, such a particular solution enables one to easily develop analytical solutions corresponding to any two-dimensional domain occupied by an isotropic linear thermoelastic solid. The accuracy and convergence of the proposed MFS-MPS procedure are validated by considering three numerical examples. It should be mentioned that [12] contains preliminary results of article [9].

In [8], we propose efficient fast Fourier transform (FFT)-based algorithms using the MFS for the numerical solution of certain problems in planar thermoelasticity. In particular, we consider problems in domains possessing radial symmetry, namely disks and annuli and it is shown that the MFS matrices arising in such problems possess circulant or block-circulant structures. The solution of the resulting systems is facilitated by appropriately diagonalizing these matrices using FFTs. Numerical experiments demonstrating the applicability of these algorithms are also presented in [8].

In article [5], we consider the bending theory of Mindlin type thermoelastic plates with voids. We study the temporal behaviour of the solution of the boundary-initial value problem of this theory. Assuming that the internal energy density is positive definite, relations describing the asymptotic behaviour of the Cesaro means of various parts of total energy are established. An extension of the results to a large class of thermoelastic materials with voids is also given.

b. Boundary Data Reconstruction in Two-Dimensional Linear Thermoelasticity

In [10, 13], we study the stable reconstruction of the missing thermal and mechanical fields on an inaccessible part of the boundary for two-dimensional linear isotropic thermoelastic materials from over-prescribed noisy (Cauchy) data on the remaining accessible boundary. This problem is solved with the MFS together with the MPS via the MFS-based particular solution for two-dimensional problems in uncoupled thermoelasticity developed in Marin and Karageorghis [9, 12]. This inverse problem is ill-posed in the sense of Hadamard. Its stabilisation/regularization is achieved by using the Tikhonov regularization method (Tikhonov and Arsenin, 1986), whilst the optimal value of the regularization parameter is selected by employing Hansen’s L-curve method (Hansen, 1998). More precisely, the thermal problem is firstly solved and hence the unknown boundary temperature and heat flux, as well as the internal temperature distribution are determined. This MFS approximation of the thermal field of the solid determines a particular solution of the non-homogeneous mechanical equilibrium equations associated with an isotropic linear thermoelastic material, see [9, 12], which actually determines appropriate Cauchy conditions for the
homogeneous equilibrium equations of isotropic linear elasticity (the Lame or Cauchy-Navier system). Consequently, in the second step one has to solve a Cauchy problem for the homogeneous Lame system of isotropic linear elasticity using yet again the Tikhonov regularization method. Finally, the superposition principle is applied to obtain the solution of the non-homogeneous mechanical Cauchy problem. The accuracy, convergence and stability properties of the proposed MFS–MPS–Tikhonov regularization method were investigated by considering four numerical examples in simply and doubly connected domains with either a smooth or a piecewise smooth boundary.

c. Boundary Reconstruction in Linear Thermoelasticity

In [6], we propose a new moving pseudo-boundary method of fundamental solutions (MFS) for the determination of the boundary of a void. This problem can be modeled as an inverse boundary value problem for harmonic functions (i.e. for thermal loadings). The algorithm for imaging the interior of the medium also makes use of radial polar parametrization of the unknown void shape in two dimensions. The center of this radial polar parametrization is considered to be unknown. We also include the contraction and dilation factors to be part of the unknowns in the resulting nonlinear least-squares problem. This approach addresses the major problem of locating the pseudo-boundary in the MFS in a natural way, because the inverse problem in question is nonlinear anyway. The feasibility of this new method is illustrated by several numerical examples.

The numerical method introduced and implemented for isotropic solids subject to thermal loads in [6] has been extended not only to two-dimensional anisotropic solids subject to thermal loads [11], but also to two-dimensional isotropic solids subject to mechanical loads [3]. The features of the thermal inverse problem [6] have been also kept in the case of the mechanical inverse problem [3], with the mention that as far as the inverse problem is concerned, the stable and accurate detection of small voids (say with characteristic diameter less than 10% of the host medium) may be viewed as a limitation of the present method and for retrieving very small defects one has to use a different approach, e.g. based on asymptotic expansions. This limitation of the proposed algorithm is caused by the fact that, for very small voids, the singularities corresponding to the internal boundary cluster and lead to a very large condition number of the MFS matrix which produces major instabilities.

In [7], we propose a new moving pseudo-boundary MFS for the determination of the boundary of a three-dimensional void (rigid inclusion or cavity) within a conducting homogeneous host medium from over-determined Cauchy data on the accessible exterior boundary. The full merits of employing a meshless method, namely, ease of implementation, speed and accuracy, over more traditional domain or boundary discretisation methods become more evident in the solution of three-dimensional inverse problems. The numerical solution of such problems by the latter, mesh-dependent methods may become prohibitive due to the large number of times (iterations) an expensive direct solver has to be called. The algorithm for imaging the interior of the medium also makes use of radial spherical parameterization of the unknown star-shaped void and its centre in three dimensions. We also include the contraction and dilation factors in selecting the fictitious surfaces where the MFS sources are to be positioned in the set of unknowns in the resulting regularized nonlinear least-squares minimization. The feasibility of this new method is illustrated in several numerical examples. The numerical results obtained show that the numerical method is accurate (for no noise) and stable with respect to noise added in the input data.

In the first part of paper [5], we elaborate on a theoretical framework for elasto-plastic materials based on the decomposition of the second-order deformation associated with the motion into its elastic and
plastic second-order components, and applied to solids with lattice defects at the micro-structure level. Only the dislocations have been considered as possible lattice defects, which are modelled through the non-zero torsion of the plastic connection as a tensorial measure of the dislocations and the scalar dislocation density and its gradient. The non-local evolution equations for the scalar dislocation density, as well as the plastic distortion, have been derived to be compatible with the principle of the imbalance of the free energy. A coupling term dependent on the gradient of the scalar dislocation density influences the evolution of the plastic distortion. The internal power includes the power dissipated by micro-forces, which consists of the micro-stress and micro-momenta satisfying their own balance equations and being related not only to the plastic distortion, but also to the scalar dislocation density. The free energy is defined to be dependent on the elastic strain and the second-order plastic deformation, as well as the scalar dislocation density and its gradient. Various constitutive non-local dissipative models have been derived and compared with the already existing ones.

Principal Investigator       3 December 2012

Dr. Liviu MARIN

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