Scientific Report

On the implementation of the Grant in the period January – December 2012

In the setting of the Grant PN-II-ID-PCE-2011-3-0211, director CS 1 Dr. Dan Tiba (Institute of Mathematics, Romanian Academy, Bucharest) the activities of the year 2012 (the first year) followed the proposals from the project submitted during the Grants competition. The members of the team are CS 1 Dr. Dan Tiba (director), Prof. Dr. Andrei Halanay, (Univ. Politehnica, Bucharest) doctorand Diana Merlusca (Institute of Mathematics, Romanian Academy, Bucharest). In the setting of the Grant, Prof. Dr. Viorel Arnautu (Univ. "Al.I.Cuza" Iasi) was active for a period of nine months (as indicated in the project) as expert in numerical approximation problems. In the autumn of 2012, Roxana Nicolai (who finished her Master in July 2012) started her PhD studies at November 1-st, 2012, at the Institute of Mathematics, Romanian Academy, Bucharest, supervisor CS 1 Dr. Dan Tiba. According to the Grant project (from the competition in 2011) Roxana Nicolai will occupy the free position for a PhD. Student, starting from the next step in 2013.

As Prof. Dr. Andrei Halanay obtained as well in the 2011 competition a similar Grant, where he is director, and Merlusca Diana obtained an European grant of type POSDRU (after the 2011 grant competition), they activated in the setting of Grant PN-II-ID-PCE-2011-3-0211 in a smaller measure as initially previewed. To remedy this situation, starting with April 2012, CS 1 Dr. Vasile Dragan from the Institute of Mathematics, Romanian Academy, Bucharest, is employed (with the observance of all the legal conditions valid in such a case). I underline that Vasile Dragan is a well known specialist in optimal control theory and is very active in the Grant project, helping already at the realization of its objectives. For detailed information on CS 1 Dr. Vasile Dragan, one may consult international data bases like ISI or AMS (MathSciNet).

The activity inside the Grant has as main product six papers published in 2012 (among which four have influence score in the list from January 2012 of ANCS, as follows : 2.03, 1.83, 1.71, 0.81) by the senior members of the Grant team, alone or in colaboration with well known mathematicians as Luciano Pandolfi (Italy), Pekka Neittaanmaki (Finland) and Juergen Sprekels (Germany). Other articles are in an advanced stage of elaboration, and involving as well international cooperation. They will be reported in the next step of the Grant, after realization and publication.

The general themes of the articles (and of the communications and lectures sustained by the team members – we shall discuss this below) are shape optimization (especially methods involving fixed domains) and optimal control (including the control variational method), according to the Grant project. Dan Tiba was invited one month at BCAM, Bilbao (prof. Enrique Zuazua), Andrei Halanay was invited one week at the la Univ. Mulhouse (prof. Cornel Murea) for projects in mathematical research and PhD student Merlusca Diana participated in the summer school from Pisa (June 2012) devoted to shape optimization. Dan Tiba was invited speaker at the French-Romanian Conference, August 2012, Bucharest and delivered a conference at BCAM, May 2012, during the above mentioned visit. All these actions were entirely financed by sources exterior to the Grant PN-II-ID-PCE-2011-3-0211.

In the setting of the Grant, we mention the participation at international conferences and the presentation of communications devoted to special subjects by Vasile Dragan (Univ. de Vest, Timisoara, July 2012), Dan Tiba (WCECS/ICMSC 2012, Berkeley, October 2012). Dan Tiba had as well a plenary lecture at CIRM Luminy (June 2012). Diana Merlusca performed documentation/research visits at the Univ. of Iasi (May and September 2012, prof. V. Arnautu) and Dan Tiba performed scientific cooperation visits at the Univ. of Iasi (October 2012, prof. V. Arnautu) and Univ. Mulhouse (November 2012, prof. C. Murea).

All the members of the Grant team (excepting prof. V. Arnautu from the Univ. of Iasi) have given numerous scientific communications and lectures in our seminar on "Differential Equations and Control Theory" from the Institute of Mathematics, Romanian Academy, Bucharest. PhD student Merlusca Diana finished all the examinations and reports and is now in an advanced phase of writing her first scientific article. Roxana Nicolai has already started her program of study for the preparation of the examinations specific to the first year as a PhD student. I add that prof. P.Neittaanmaki (Univ. Jyvaskyla) made a visit to the Institute of Mathematics, Romanian Academy, Bucharest, September 2012 to continue the scientific collaboration with Dan Tiba. In the setting of his visit he sustained a lecture in the seminar "Differential Equations and Control Theory" dedicated to methods in the efficient numerical approximation of differential equations.

Dan Tiba is as well the co-director of a French-Romanian Grant of type "Brincusi" (period 2011-2012) together with Murea Cornel, Univ. Mulhouse, France. Moreover, in collaboration with Murea Cornel, Dan Tiba proposed the organization of a scientific minisession with international participation (and with good chanches to be accepted) at the IFIP international conference from Klagenfurt, Austria, September 2013.

PAPERS PRESENTATION

A) Articles with influence score

1) Dan Tiba, Juergen Sprekels, **Extensions of the control variational method**, Control and Cybernetics, vol. 40, no.4 (2011), p. 1099-1108., influence score 0.81.

This article was in fact published around the middle of the year 2012 since the respective journal appears with a certain delay. The article is mentioned here for the first time. It is a sequel of many papers published by Sprekels and Tiba on the control variational method and is part from the subject of this Grant. The control variational method is a new variational method based on optimal control theory (the maximum principle of Pontryagin) for the study and the solution of boundary value problems for differential equations. The method was introduced and investigated in the last ten years, especially by contributions of the authors Juergen Sprekels and Dan Tiba together with their collaborators. In this article, we analyze the possible application of the control variational method for parabolic equations starting from their semidiscretization via elliptic equations. We indicate convergence results and global formulations for certain weak solutions.

2)Dan Tiba, Pekka Neittaanmaki, **Fixed domain approaches in shape optimization problems**, Inverse Problems, vol.28, p.1-35, doi:10.1088/0266-5611/28/9/093001, influence score 1, 83

This is an ample article, in a very good journal at the international level and its publication is a confirmation of the prestige of the authors in this area of mathematical research. The theme of the article refers to one of the central objectives proposed for the Grant PN-II-ID-PCE-2011-3-0211. Shape optimization problems are governed by partial differential equations (the elliptic case is very important) and the domain where these equations are defined is the main unknown of the problem. The optimal domain is searched via the minimization of a certain cost functional, usually of integral type. This specific characteristic (unknown domains) renders the shape optimization problems extremely difficult from the numerical point of view or for theoretical discussion. The article presents numerous methods and results which allow the replacement or the approximation of such problems by problems defined in a special way, in some fixed domain. Geometric controllability properties, optimal control methods, convergence results are indicated together with numerical experiments that test the efficiency of the new proposed methods.

3) Andrei Halanay, Luciano Pandolfi, **Lack of controllability of the heat equation with memory**, Systems and Control Letters, vol.61, no.10, p. 999-1002 (2012), influence score 2,03

In this paper a model for the heat equation with memory is considered that preserves the infinite propagation speed property as in the case of the classical heat equation. It is proved that for any *T>0* there are square integrable initial conditions that cannot be controlled to reach the null value at time *T* via square integrable controls. The indicated counterexample observes the restrictions imposed by the second law of thermodynamics. This is based on the characterization of the biorthogonal sequence to the restriction of the sequence that generates the Muntz space on the interval *[0,T]* and on a theorem of Laurent Schwarz concerning the isomorphism between the Muntz space and the space of the restrictions to the interval *[0,T].*

4) Vasile Dragan, **Optimal Filtering for Discrete-Time Linear Systems with Multiplicative White Noise Perturbations and Periodic Coefficients** IEEE TRANSACTIONS ON AUTOMATIC CONTROL, DOI: 10.1109/TAC.2012.2215534., influence score 1,71

For this article, the galley proofs have already been sent, but we still don't know the complete references. The objective is to obtain via general variational techniques efficient numerical methods for the computation of periodic solutions for Lyapunov equations with periodic coefficients that appear in deterministic and stochastic control problems. Usual numerical methods cannot be applied in this case since no initial or final value of the solutions are known. We have considered an optimal filtering problem of a signal generated by a dynamical system in discrete time, under the action of external perturbations given by additive and multiplicative white noise. The analogous of a Kalman filter for this type of systems is not possible to be used since the coefficients are affected by the white noise that appears in the mathematical model of the system to be estimated. Consequently, we have reformulated the optimal filtering problem by looking for the filter in the class of the deterministic dynamical systems with discrete time and arbitrary dimension for the state space. The optimal filter with respect to this class of admissible filters has the representation in the space state built with the help of a stabilizing solution of a Riccati equation in discrete time and with periodic coefficients. The coefficients of this Riccati equation are obtained using the unique periodic solution of a perturbed Lyapunov equation. Consequently, to determine the equations of the optimal filter we have to compute the unique periodic solution of a Lyapunov equation in discrete time.

B) Papers in Proceedings volumes

1) Dan Tiba, **Optimal Control Approaches for Some Geometric Optimization Problems,** Lecture Notes in Engineering and Computer Science: Proceedings of WCECS 2012, 24-26 October, 2012, San Francisco, USA, S. I. Ao, Craig Douglas, W. S. Grundfest and Jon Burgstone Editors, Newswood Limited, Hong Kong, p.1248-1252, ISBN 978-988-19252-4-4

This paper is devoted (as the title shows) to optimal control methods in optimal design problems. The general idea is to solve geometric optimization problemsvia analytic methods that are easier to implement on a computer. The presentation includes both theoretical results and numerical experiments. We underline that the subject of the paper is strictly related to the objectives of the Grant.

2) Dan Tiba, **Finite element discretization in shape optimization problems for the stationary Navier-Stokes equation,**in "System Modeling and Optimization": 25th IFIP TC 7 Conference, Berlin, Germany, September 12-16, 2011, Revised Selected Papers, D.Hoemberg and F.Troltzsch Eds.,IFIP AICT 391, Springer, Heidelberg, p. 437-444 (2013).

The Conference was organized in September 2011 and the paper was accepted for publication in the middle of 2012. The galley proofs were made in November 2012 and the volume will be published in January 2013 at the well known publishing house Springer Verlag. We analyze a fixed domain method for the discretization of shape optimization problems governed by stationary Navier-Stokes equations. We establish convergence results for the discrete solutions and for the approximating opimal values. The paper is strictly related to the objectives of the Grant.

Director,

CS 1 Dr. Dan Tiba

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