Talal Rahman

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Personal Data

1.1 Name: Talal Rahman.

1.2 Date of birth: 02 November 1963.

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1.6 Present employment:

- Professor of Mathematics, Bergen University College 03/2012 - present.

1.7 Previous employments:

- Associate Professor of Mathematics, Bergen University College 07/2009 - 03/2012.
- Senior Researcher, CIPR, Uni Research, Norway 03/2008 - 06/2009.
- Associate Professor, Mathematics, University of Bergen, Norway 09/2007 - 12/2007.
- Postdoc, Mathematics, University of Bergen, Norway 02/2006 - 02/2008.
- Research Scientist, Bergen Center for Comp. Sci., Norway 05/2004 - 01/2006.
- Postdoc, Mathematics, University of Augsburg, Germany 09/2000 - 08/2003.
- PhD Research Fellow, University of Bergen, Norway 04/1996 - 03/2000.
- Research Scientist, Parallab, Norway 10/1994 - 03/1996.

Visiting scholar:

- University of Cambridge, DAMTP, UK 02/2012 – 07/2012
- Academy of Sciences, Inst. of Computational Math., Beijing, China 12/2008 – 01/2009
- Institute for Mathematics and Application (IMA), Minnesota, USA 03/1997 – 06/1997

Short term visits:

- Lund University, Department of Mathematics, Faculty of Engineering, Sweden
- Princeton University, Department of Civil and Environment Engineering, USA
- University of Bath, Department of Mathematics, UK
- University of Warsaw, Institute of Mathematics and Mechanics, Poland
- University of Applied Sciences Bielfeld, Germany

Degrees, Assessments

2.1 Academic degrees including years of graduation:

- Dr.Scient. (Mathematics and Natural Sci.), University of Bergen, 06/2000.
  - Supervisor: Prof. Petter E. Bjørstad.
  - Evaluation committee:
    Professors Ronald W. Hoppe, Ragnar Winther, and Alexander Malyshev.
- Cand.Scient. (Numerical Analysis), University of Bergen, 11/1994.
- Cand.Mag. (Informatics/Numerical Analysis), University of Bergen, 06/1991.
- 1-year Course (Norwegian Language), University of Bergen, 06/1988.
- B.Engg. (Electrical and Electronic), Bangladesh University of Engg. Tech., 06/1987.

2.2 Professorial competence

- Norwegian professorial competence 03/2012
  - Evaluation committee:
    Professors Hans Munthe-Kaas, Gunilla Kriess, and Martin Gander.
- French professorial competence 02/2012
  Professeur des Universités - Mathématiques appliquées et applications des mathématiques.
  - Evaluation committee: Professors Alain Trouve and Jean-Francois Aujol.

2.5 Other information

- Declined job offers:
  - Permanent position as sen. researcher at Uni-Research - CIPR, Univ. Bergen, 2009
  - Research position (tenured track), Center for Mathematics, Univ. Coimbra, 2008.
- Short listed:
  - Position of associate professor in Appl. Math., Univ. Bergen, 2009
  - Position of university lecturer in Appl. Math. (numer. anal.), Lund Univ., 2010.

SCIENTIFIC MERITS

3.1 Brief account of own research profile:

With the primary focus on solving large and complex engineering problems, much of my research has revolved around looking for fast and effective algorithms for the numerical solution, while a part has been about appropriate numerical models, in particular for problems in fluid simulation and image processing.

Throughout my research, I have only been inspired by problems with strong importance for the engineering application, and have enjoyed collaborations with several leading researchers and research groups in the field of computational mathematics. Some of the key problems, which I have considered in my research, include problems with highly discontinuous coefficients, representing, for instance, the permeability of rock in the reservoir, problems having complex geometries and requiring to be discretized independently in different regions of the domain, as for instance, in the handling of domain with cracks in the reservoir, problems where the fluid behaves anisotropic, as for instance, in control devices, etc. .

When it comes to solving such problems numerically, a general framework for developing effective numerical solver, commonly known as the domain decomposition, has been the key source of inspiration in my research. The framework not only provides effective means to solve problems but also the possibility for mathematical analysis of the methods. Even now, popular multiscale methods, like the multiscale finite element method, the heterogeneous multiscale method, and the variational multiscale method, which were developed without any reference to the domain decomposition framework, are now being seen as a special case of the framework. This has been the motivation for my new research projects.

Some of my early research has been based on a special discretization technique known as the Mortar method, which can be used to glue finite elements along interfaces where the grids are non-matching, adding flexibility to the standard discretization technique.

Below, I list some of my research work, 15 of the peer reviewed articles from journals, lecture notes and proceedings. The articles are collected in three groups: Group-1 ([J02, J01, J03]) corresponds to my doctoral research, Group-2 ([J04, J06, J10, J09, J15, J08, J11]) corresponds to the continuation of my doctoral research, demonstrating depth in the research, and Group-3 ([L05, J14, L06, J05, J07]) corresponds to other thematic works, demonstrating breadth in the research.

Group-1: Doctoral research

The key area of my doctoral research had been additive Schwarz methods, focusing particulary on problems where the coefficients can be discontinuous and anisotropic, as well as problems where the discrete formulations can be based on grids that are non-matching across subdomain interfaces. In all cases I performed the convergence analysis of the domain decomposition methods based on the classical Schwarz framework.

Additive Schwarz for elliptic PDEs:

The simplest, yet, among the most effective of all domain decomposition algorithms is the additive Schwarz algorithm. Such algorithms can be seen as solving, instead of the original system, an equivalent system, referred to as the preconditioned system, with better numerical properties. One key ingredient in the design of an additive Schwarz algorithm is the coarse problem. Chosing a proper coarse problem and an appropriate solver for the problem is crucial to get an algorithm that is scalable, robust and efficient. This has been my primary focus. In addition, I focussed on coarse problems that are particulary suitable for unstructured coarse grids.

Article [J02], which appeared in the journal Journal of Numerical Mathematics, contains my first convergence analysis, and an interesting contribution to the theory of domain decomposition, proposing an additive Schwarz method for the biharmonic problem. The results of the article was unique and interesting in the sense that it was the first method to achieve a condition number bound which was shown at the time by S. Brenner to be the theoretical lower bound for additive Schwarz methods for the biharmonic equation. The article first appeared as an IMA technical report (Institute for Mathematics and its Application, Minneapolis, USA), and later, its improved version, as the journal article.

In my next work I wanted to see how the domain decomposition framework could be applied to generate an effective algorithm where the coefficients are not only discontinuous across subdomain boundaries, but also anisotropic. This was done by appropriately solving one coarse problem in each direction. The work appeared as a chapter in the IMA volume in Mathemaics and its Applications, cf. [J01]. To our knowledge no similar work existed then.

Additive Schwarz for Mortar FE on non-matching grids:

The third article, which appeared in the journal Numerische Mathematik, cf. [J03], constitutes an important contribution to the theory of domain decomposition (the article is listed in Domain Decomposition Methods - Algorithms and Theory, by A. Toselli and O. Widlund, a book which is used extensively). The work is based on extending the additive Schwarz method with minimal coarse space to the discretization with non-matching grids. The intriguing part lies in the way the coarse basis functions were defined on the master and the slave sides.

Group-2: Doctoral research extended

In the post doctoral period, my research took two main routes. Besides further extending my research on domain decomposition methods, I also developed an interest for the non-conforming finite element, namely the Crouzeix-Raviart FE, which ended up being one of my favorite elements for the numerical solution due to its several useful features as compared to other finite elements. In almost all cases I performed the convergence analysis of the domain decomposition methods based on the classical Schwarz framework.

Domain decomposition methods:

Some of my important contributions to domain decomposition and its theory, from the post doctoral period, are listed here.

The first on the list is the article on a two-level additive Schwarz method for a non-linear problem which appeared in the journal IMA Journal of Numerical Analysis, cf. [J04]. Non-linear problems are in general difficult to solve numerically, domain decomposition techniques can often be used, however, it requires a careful design, and the analysis may not be straightforward. In [J04], we proposed a two-level additive Schwarz method for the solution of a non-linear Biharmonic equation, where we adapt a simple approach putting the non-linear term in the right hand side and solving linear problems in each iteration. Using a standard analysis, we showed that the method is optimal for sufficiently small Reynolds number, in the sense that its convergence does not depend on the mesh sizes.

The next article, cf. [J06], which appeared in the journal Numerische Mathematik, was my first work on the CR finite element, representing in some sense an extension of the work [J03] from my doctoral research. However, I had to deal with the new and intriguing part in the analysis, namely, the non-conformity of the CR finite element, while proving the same convergence rate as the conforming counter part. This work triggered the need for an approximate mortar condition for the CR mortar finite element, which later resulted in the article [J08], see below.

The next three articles are on domain decomposition methods based on three independent approaches for the Crouzeix-Raviart mortar finite element, the first one appearing in the journal ESAIM-M2AN, cf. [J10], the second one in the journal BIT Numerical Mathematics, cf. [J09], and the third one is to appear in the journal Computational Methods and Applied Mathematics, cf. [J15]. The first article demonstrates the idea of using an existing multilevel preconditioner for the P_1 mortar finite element (i.e. mortar with P_1 conforming) to precondition the CR mortar finite element (i.e. mortar with CR or P_1 non-conforming), thereby avoiding to directly deal with the non-conformity of the CR finite element yet retaining the same convergence rate as in the conforming case. The second article is on a substructuring type domain decomposition method, called the Neumann-Neumann, whose convergence rate depends logarithmically on the ratio between the subdomain size and the mesh size resulting in a fast and effective method for large problems. The convergence analysis, however, needed a careful dealing with the non-conformity. The third article is on a FETI-DP algorithm with the primal constraint being defined as the continuity at nodes closest to the cross points. The method has a convergence which is comparable to the Neumann-Neumann method. It is worth mentioning here that these articles on the CR finite element are first of their kind.

CR-mortar with approximate mortar condition:

If we use the standard mortar condition for the Crouzeix-Raviart finite element on non-matching grids, the basis functions lying close to a subdomain interface then cease to have local support which is undesirable. I introduced an interpolation operator on the interface, which replaces the traditional mortar condition with an approximate one, giving back the local support and yet providing the same optimal error estimate as in the exact case. The work appeared in the journal Siam Journal of Numerical Analysis, cf. [J08], being one of few works on approximate mortar condition adapting non-standard approaches to numerical methods in order to improve their algorithms. In fact, for the CR mortar finite element to be of any practical use, this is indeed quite necessary, particularly in three dimensions. The extension of this approach to higher dimensions later appeared in the journal Computing, cf. [J11]. The idea can be generalized to other finite elements of non-conforming type providing ways to generate effective algorithms with such elements on non-matching grids.

Group-3: Secondary research

Image processing is among other interests which I am currently pursuing. I got involved in its research only a few years ago, however, it has turned into one of my favorites. The beauty of mathematical imaging and the spell it casts on digital imaging is what keeping me interested in the field. Before getting into imaging, I had the opportunity to work on a slightly different topic, namely the numerical study of nonlinear fluid.

Image processing:

The problems in image processing are defined as inverse problems. Typically the data is the image available in hand which may be noisy, blurry, or with missing parts etc.. The aim is to recover the original image.

One can derive some similarity between the anisotropic fluid flow and the image processing in 2D. Based on this similarity, we (I and my collaborators) proposed a two-step model for the image restoration known as the TV-Stokes (or TV-Stokes L_2), using two Total Variation minimizations with the constraint that the isophote lines are divergence free (similar to the incompressibility condition in fluid flow), and producing images which are often visually pleasant. The work appeared as a Lecture Note in Computer Scinece, cf. [L05].

After its publication in 2007, the work [L05] started to attract attention, and the need for an analysis of the model became therefore inevitable. The article [J14] thus emerged, which appeared in the journal Siam Journal of Scientific Computing, and contained the first ever analysis of a two step model for image processing as well as an efficient finite element implementation of the model demonstrating its superiority over the finite difference implementation (strangely enough, finite elements are rarely used in image processing). Due to non-coercivity of the functional in the second step, the functional had to be slightly modified in order to get a problem which was well-posed without degrading much the overall performance. However, it seems now that the existence of a unique solution may still be proved for the original functional using the Gamma-convergence theory, this is subject to future work.

A dual formulation of the TV-Stokes model and a fast Fourier solver for the Laplacian resulted in an extremely fast algorithm. This work appeared as a lecture Note in Computer Science, cf. [L06]. The convergence analysis of the algorithm in the 2D case has been prepared and is under the process of being submited to a journal, cf. [S05]. An extension of the algorithm in multidimension also exists now, and is under the process of being submitted as well, cf. [S04].

Non-linear fluid simulation:

In the simulation of smart fluids, like the Electro-Rheological Fluid, a challenge is to be able to correctly model their nonlinear viscoelastic nature, as well as to capture their anisotropic behavior. A model using a nonlinear viscosity function in order to capture the anisotropic behavior of the fluid was proposed by Litvinov and Hoppe in one of their papers. My task was to propose an efficient numerical method for the model, which I did, basing it on the use of augmented Lagrangian method combined with an operator splitting technique, proving its convergence, and then applying it to study numerically the behavior of the fluid in an ERF clutch and an ERF shock absorber. The works appeared in the journals Siam Journal of Applied Mathematics, cf. [J05], and European Journal of Applied Mathematics, cf. [J07], respectively.

3.2 Brief account of planned research effort:

Numerical methods that can capture the multiscale nature of the solution (e.g. in modelling flow in porous media, optimizing biochips under PDE constraints) in effective ways, and methods that can model vital image processing tasks (e.g. in medical imaging) appropriately, will continue to stay among the most important and thriving topics of research in computational mathematics in the coming years, since they are central to computing for technologies like the energy, the environmental, and the medical. In my research, I intend to work on such topics.

Multiscale domain decomposition: My interest in numerical methods for multiscale problems started with my engagement in a project led by J. Nordbotten, in the Department of Mathematics at the University of Bergen, whose primary goal was to develop effective ways to solve the porous media flow problem through the application of some of the most effective iterative methods, like the domain decomposition, and by capturing in each iteration the multiscale feature of the flow in an appropriate way. Although the project was aimed at problems in porous media flow, such methods have a much wider application.

Currently, with my collaborators and PhD students, I am looking into the possibilities to develop and analyze multiscale methods in the framework of domain decomposition methods. This is the primary goal of a project which I am a co-Principal Investigator (with Petter Bjørstad) of, namely the project "Multiscale Domain Decomposition - Algorithms and Analysis" financed by the Norwegian Research Council (2010-2014, extended till 2005). The project involves two PhD students (due in 2014 and 2015), one Postdoctor student. One PhD student from the Chinese Academy of Sciences, Beijing, was also involved in the project,and who recently defended his thesis. As a result, five articles, two of them addressing a two-level additive Schwarz and a FETI-DP method for the symmetric multiscale problem in a discontinuous Galerkin formulation, cf. [S07, S06], and the rest addressing two-level additive Schwarz methods for the nonsymmetric problem resulting from a control volume formulation, cf. [S03, S02, S01], are submitted or in the process of being submitted to journals.

Multi-scale methods have been successfully applied to a range of linear problems, however, it is not quite understood for nonlinear problems. I plan to continue my work on numerical methods for multiscale problems that are linear, as well as extend those ideas to certain nonlinear problems. An active collaboration with the reservoir group (J. Nordbotten) in the Department of Mathematics at the University of Bergen is expected of me.

Image processing: Image denoising, -in-painting, -segmentation and -registration are the classical image processing tasks. Two-step approaches like the TV-Stokes model is proving to be quite effective in many cases, and has therefore started to attract more and more attention. The functional to be minimized in the TV-Stokes model does not make any sense in the space of bounded variations unless some assumption on the smoothness of the normal vector field has been made. My intention is to study the model further, explore the assumptions on the smoothness, prove the well-posedness, extend the model to TV-Stokes L_1, TV-stokes H^{-1}, and TV-Stokes blurring models, and develop algorithms using domain decomposition as well as the multiscale approach. A multiscale approach in image processing may turn out to be an extremely effective technique for improved representation of the image. In some image processing problems such an approach seems to have already been quite effective.

With regards to research collaboration, I have an active relation with the image processing group (X.-C. Tai and A. Malyshev) in the Department of Mathematics at the University of Bergen. X.-C. Tai is a co-supervisor of one of my PhD students who is financed by the Bergen University College. Also, in the spring semester 2012, I visited Carola-Bibiane Schönlib in DAMTP at the University of Cambridge, which resulted in initiating a research collaboration focussing on multiscale and domain decomposition methods for image processing. I plan to continue my research on developing appropriate models and computational methods for image processing, and apply them to problems, e.g., in bio-medical imaging.

3.3 List of publications:

3.3.1 Peer reviewed:

Submitted or in the process of being submitted to journals for review

[S07] Y. Ma, P. Bjørstad, T. Rahman, and X. Xu, *Domain decomposition preconditioners for a discontinuous Galerkin formulation of a multiscale elliptic problem.* (Available online arXiv:1203.4044 [math.NA]).

[S06] R. Du, Y. Ma, T. Rahman, and X. Xu, *A FETI-DP preconditioner of discontinuous Galerkin method for multiscale problems in high constrast media.* (Available online arXiv:1405.3555 [math.NA])

[S05] C.A. Elo, A. Malyshev, and T. Rahman, *On the dual formulation of the TV-Stokes minimization.* (Being added to the arXiv)

[S04] A. Malyshev and T. Rahman, *Multi-dimensional TV-Stokes.* (Being added to the arXiv)

[S03] L. Marcinkowski, T. Rahman, and J. Valdman, *Additive Schwarz preconditioner for the general finite volume element discretization of symmetric elliptic problems.* (Available online arXiv:1405.0185 [math.NA])

[S02] A. Loneland, L. Marcinkowski, and T. Rahman, *Additive average Schwarz method for a Crouzeix-Raviart Finite Volume Element Discretization of Elliptic Problems with Heterogeneous Coefficients.* (Available online arXiv:1405.3494 [math.NA])

[S01] A. Loneland, L. Marcinkowski, and T. Rahman, *Edge based Schwarz methods for the Crouzeix-Raviart finite volume element discretization of elliptic problems.* (Available online arXiv:1405.2741 [math.NA])

Journal Articles (peer reviewed)

[J16] T. Rahman and J. Valdman, *Fast Matlab assembly of FEM stiffness and mass matrices in 2D and 3D: nodal elements.* **Appl. Math. Comp.**, vol. 219(13), 2013, pp. 7151–7158.

[J15] L. Marcinkowski and T. Rahman, *A FETI-DP method for Crouzeix-Raviart finite element discretization.* **CMAM**, vol. 12(1), 2012, pp. 73-91.

[J14] W. Litvinov, T. Rahman, and X.-C. Tai, *A modified TV-Stokes model for image processing.* **SIAM J. Sci. Comp.**, vol. 33, 2011, pp. 1574-1597.

[J13] T. Rahman, *Schwarz preconditioned CG algorithm for the mortar finite element.* **Numerical Algorithms**, vol. 58, no. 2, 2011, pp. 235-260.

[J12] J. Nordbotten, T. Rahman, S. Repin, and J. Valdman, *A posteriori error estimates for approximate solutions of Barenblatt-Biot poroelastic model.* **CMAM**, vol. 10, no. 3, 2010, pp. 302-314.

[J11] L. Marcinkowski, T. Rahman, and J. Valdman, *A 3D Crouzeix-Raviart mortar finite element.* **Computing**, vol. 86, no. 4, 2009, pp. 313–330.

[J10] T. Rahman and X. Xu, *A multilevel preconditioner for the mortar method for nonconforming P1 finite element.* **ESAIM-M^{2}AN**, vol. 43, no. 3, 2009, pp. 429–444.

[J09] L. Marcinkowski and T. Rahman *Neumann-Neumann algorithms for a mortar Crouzeix-Raviart element for second order elliptic problems.* **BIT Numer. Math.**, vol. 95, 2008, pp. 427–457.

[J08] T. Rahman, P. E. Bjørstad and X. Xu, *The Crouzeix-Raviart FE on nonmatching grids with an approximate mortar condition.* **SIAM J. Numer. Anal.**, vol. 46, 2007/2008, pp. 496–516.

[J07] W. Litvinov, T. Rahman, and R. Hoppe, *Model of an electro-rheological shock absorber and coupled problem for partial and ordinary differential equations with variable unknown domain.* **Europ. J. Appl. Math.**, vol. 18, 2007, pp. 513–536.

[J06] T. Rahman, X. Xu, and R. Hoppe, *An additive Schwarz method for the Crouzeix-Raviart mortar finite element for elliptic problems with discontinuous coefficients.* **Numerische-Mathematik**, vol. 101, no. 3, 2005, pp. 551–572.

[J05] R. Hoppe, W. Litvinov, and T. Rahman, *Problems of stationary flow of electro-rheological fluids in the cylindrical coordinate system.* **SIAM J. Appl. Math.**, vol. 65, no. 5, 2005, pp. 1633–1656.

[J04] X. Xu, S. H. Lui, and T. Rahman, *A two-level additive Schwarz method for the Morley nonconforming element approximation of a nonlinear biharmonic equation.* **IMA J. Numer. Anal.**, vol. 24, 2004, pp. 97–122.

[J03] P. E. Bjørstad, M. Dryja, and T. Rahman *Additive Schwarz methods for elliptic mortar finite element problems.* **Numerische Mathematik**, vol. 95, 2003, pp. 427–457.

[J02] X. Feng and T. Rahman, *An additive average Schwarz method for the plate bending problem.* **J. Numer. Math.**, vol. 10, 2002, pp. 109–125.

[J01] P. E. Bjørstad, M. Dryja, and T. Rahman, *Additive Schwarz for anisotropic elliptic problems.* **IMA Vol. Math. Appl.**, vol. 120, Springer-Verlag, 2000, pp. 279–294.

Lecture Notes (peer reviewed)

[L10] L. Marcinkowski, A. Loneland, and T. Rahman, *Schwarz methods for a Crouzeix-Raviart finite volume element discretization of elliptic problems.* **Lecture Notes in Computational Science and Engineering**, Springer Verlag, 2014. (Accepted, to appear)

[L09] A. Loneland, L. Marcinkowski, and T. Rahman, *Additive average Schwarz method for the Crouzeix-Raviart finite volume element discretization of elliptic problems.* **Lecture Notes in Computational Science and Engineering**, Springer Verlag, 2014. (Accepted, to appear)

[L08] L. Marcinkowski and T. Rahman, *Parallel preconditioner for the finite volume element discretization of elliptic problems.* **Lecture Notes in Computer Science**, vol. 8385, Springer Verlag, 2014, pp. 469–478.

[L07] L. Marcinkowski and T. Rahman, *A parallel preconditioner for a FETI-DP method for the Crouzeix-Raviart finite element.* **Lecture Notes in Computational Science and Engineering**, Springer Verlag, 2013. (Accepted, to appear)

[L06] [1] C. Elo, A. Malyshev, and T. Rahman, *A dual formulation of the TV-Stokes algorithm for image denoising.* **Lecture Notes in Computer Science**, vol. 5567, Springer-Verlag, 2009, pp. 307–318.

[L05] [1] T. Rahman, X.-C. Tai, and S. Osher, *A TV-Stokes denoising algorithm.* **Lecture Notes in Computer Science**, vol. 4485, Springer-Verlag, 2007, pp. 473–483.

[L04] T. Rahman, and X. Xu, *A new variant of the mortar technique for the Crouzeix-Raviart finite element.* **Lecture Notes in Computational Science and Engineering**, vol. 55, Springer Verlag, 2006, pp. 463–470.

[L03] T. Rahman, X. Xu, and R. Hoppe, *On an additive Schwarz preconditioner for the Crouzeix-Raviart mortar finite element.* **Lecture Notes in Computational Science and Engineering**, vol. 40, Springer Verlag, 2004, pp. 335–342.

[L02] R. Moe, T. Rahman, O. Sævareid, and R. Teigland, *Porting and parallel performance of the industrial CFD code MUSIC*. **Lecture Notes in Computer Science**, vol. 1067, Springer-Verlag, 1997, pp. 12–19.

[L01] A. Braathen, J. Cook, A.C. Damhaug, T. Rahman, and O. Sævareid. *Parallelization of the SWAN surface wave analysis code*, **Lecture Notes in Computer Science**, vol. 1067, Springer-Verlag, 1997, pp. 36–42.

Proceedings (peer reviewed)

[P02] R. Hoppe, W. Litvinov, and T. Rahman, *Mathematical modelling and numerical simulation of electrorheological devices and systems*. In **Numerical Methods for Scientific Computing, Variational Problems and Applications**, E. Heikkola, Y. Kuznetsov, P. Neittaanmäki, and O. Pironneau, eds., CIMNE, Barcelona, 2004, pp. 80–93.

[P01] P. E. Bjørstad, M. Dryja, and T. Rahman, *Efficient Schwarz methods for elliptic mortar finite element problems*. In **Domain Decomposition Methods in Sciences and Engineering**, N. Debit, M. Garbey, R. Hoppe, D. E. Keyes, Y. Kuznetsov, and J. Periaux, eds., CIMNE, Barcelona, 2002, pp. 305–312.

3.3.2 Other publications:

Technical Reports (selected)

[T05] T. Rahman and J. Valdman, *Fast MATLAB assembly of FEM matrices in 2D and 3D: nodal elements*. **Max-Planck-Institut für Mathematik in der Naturwissenschaften**, Technical report 11/2011, Leipzig, Germany, 2011.

[T04] W. Litvinov, T. Rahman, and X.-C. Tai, *A Modified TV-Stokes model for image processing*. **Institut für Mathematik, University of Augsburg**, Preprint Nr. 25/2009, Germany, 2009.

[T03] T. Rahman, X.-C. Tai and S. Osher, *A TV-Stokes denoising algorithm*. **University of California LA**, CAM Report 06-61, USA, 2006.

[T02] T. Rahman, *SERF2D-MatLab - Documentation*. **Institut für Mathematik, University of Augsburg**, Germany, 2003.

[T01] X. Feng and T. Rahman, *A nonoverlapping additive Schwarz method for the Bi-harmonic equation*. **IMA, University of Minesota**, IMA Preprint Series 1554, USA, 1998.

3.4 Research Grants:

3.4.1 Research council funds:

Co-Principal Investigator (with P. Bjørstad) 8.02M NKr, 2010-2013 extended 2015

FRINAT (Norwegian Research Council)
Project: Multi-scale Domain Decomposition: Algorithms and Analysis

Norwegian Project Leader 130K NKr, 2014-2015

DAADppp Programme (Norwegian Research Council)
Project: Efficient preconditioners for problems with multiple scales

3.4.4 Other funding:

- Small funds from R&D Bergen University College (2009/10, ..., 2014/15).
  Project: Advanced Scientific and Engineering Computing / Multiscale DD
- Travel fund from the Meltzerfondet, 2007

[1] The two lecture notes are unique publications in the sense that they are important contributions to image processing, and are being continually cited by other authors in the field, please refer to Sections 3.1 and 3.3 for details.

3.5 Other scientific achievements:

3.5.1 Active participation in national and international conferences (in the last 5 years):

Lecturing in national and international conferences and workshops:

- DD22 2013, 22nd Int. Conf. Domain Decomposition Methods, Lugano, Sept. 2013
  Lecture: *An ASM preconditioner for FV discretization of elliptic problems in 2D*
- SPOMECH 2012, Supercomputing and computational solid and fluid mechanics
  Organized by VSB-TUO and IGN, Ostrava, Czech republic, November 2012
  Invited plenary lectures:
  - *CR mortar finite element and its domain decomposition preconditioners*
  - *DD for a discontinuous Galerkin formulation of the multiscale elliptic problem*
- 11th Winter School: Mathematical and Numerical Methods for Multiscale Problems
  Organized by SINTEF, Geilo, Norway, January 2011
  Invited plenary lectures: *Domain Decomposition and Mortar Methods*
- Computational Mathematics and Applied Mathematics-4, Poznan, Poland, June 2010
  Plenary presentation: *Dual formulation of TV-Stokes algorithm for image processing*
- China-Norway-Sweden Workshop Computational Math., Bergen, Norway, June 2010
  Invited plenary lecture: *Fast alg. for constr. TV min with appl. to image proc.*
- Para 2010, University of Reykjavik, Reykjavik, Iceland, June 2010
  Lecture: *Fast alg for constrained TV min with application to image processing*
- DD Solvers for Heterogeneous Field Problems, Kleinwalstertal, Austria, June 2010
- SIAM Conference on Imaging Science, Sandiego, CA, July 2008
  Lectures
  - *Image Inpainting using a TV-Stokes Equation*
  - *Four-colour theorem and level set methods for watershed segmentation*

Organizing national and international scientific meetings:

- *Co-organizer of Workshop: Applied High Performance Numerical Algorithms in PDEs*
  PPAM 2013, Warsaw, Poland, 8.-11. September 2013
- *Co-organizer of Section: Numerical Methods of Differential Equations*
  GAMM 2013, Novi Sad, Serbia, 18.-22. March 2013
- *Co-organizer of Minisymposium: Domain Decomposition and Multiscale Methods*
  DD21 2012, INRIA Rennes-Bretagne-Atlantique, France, 25.-29. June 2012
- *Co-organizer of Minisymposium: Fast PDE Solver and A Posteriori Error Estimates*
  PARA 2010, Reykjavik, Iceland, 6.-9. June, 2010
- *Co-organizer of workshop: Multiscale Methods*
  Geilo, Norway, 4.-5. December 2008

3.5.2 Scholarships and disctinctions:

- University PhD scholarship, 1996-2000, University of Bergen
- General University Scholarship, 1982–1987, Bangladesh University of Engg. and Tech.
- Ranked 12th (with distinction) in nation wide School Certificate Exam, 1979, Bangladesh.

3.5.5 Review / referee assignments:

Mathematics of Computation, SISC, SINUM, BIT Numerical Mathematics, Numerical Methods for PDE, Applied Numerical Mathematics, Journal of Parallel and Distributed Computing, Journal of Computational and Applied Mathematics, Optimization Methods and Software, AIP Advances

3.5.6 Assignments as public examiner/opponent

Examiner for several courses, as well as opponent for several master thesis, given in the department of mathematics and informatics at the University of Bergen.

Pedagogical Merits

4.1 Account of own pedagogical experience:

Teaching has been an integral part in my career, and my teaching experience comes from teaching at higher education institutions (University of Bergen, Bergen University College) at different levels including undergraduate and graduate studies with students from different disciplines including informatics (computer science), mathematics, engineering, and biology. Bergen University College is an higher education institution responsible for educating students in the graduate and undergraduate level. Since I joined the college in July 2009, I have taught several mathematics courses to the undergraduate engineering students. I have also assisted informatics- and mathematics students in two undergraduate courses.

University of Bergen

Course Lecture — Since January 1997

- Partial Differential Equations (Fall semester 2007, -2005, and -2004)
- Finite Element- and Domain Decomposition Methods (Fall semester 2005)
- Numerical Linear Algebra (Spring semester 1997)
- Informatics (Fall semester 1998)

Teaching Assistant — September 1991 to June 1994

- Numerical Analysis (Fall semesters 1991-1993)
- Numerical Methods (Spring semesters 1992-1994)

Bergen University College

Course Lecture — Since August 2009

- Ordinary Differential Equations (Fall semester 2009, -2010, -2011)
- Linear Algebra and Analysis (Spring semester 2010 and -2011)
- Basic Mathematics for Engineers (Fall semester 2012)
- Multivariable Calculus (Spring- and Fall semester 2013, Spring semester 2014)

4.2 Personal pedagogical ideas about undergraduate and postgraduate teaching

I base my teaching on constantly finding better ways to first motivate my students, and to invite them into active participation in the learning process, e.g. through discussions and communications of their results in the classroom, thereby helping them to better understand the subject and to gradually build their self-reliance and judgement in the subject.

4.3 Own teaching effort at undergraduate and graduate level

I come prepared to the class before each lecture, and use weekly exercises as well as classroom discussions as means to monitor the progress of my students. Once I know their strengths and their weaknesses, I try to adjust my teaching accordingly in order to maximize their learning. I often consult with more experienced teachers and ask them for their advice on different matters regarding teaching and organizing courses. I always share my opinion on teaching in meetings with other colleagues.

See attached document, in Norwegian, for my teaching methods and experience in a recent mathematics course *MAT100 Basic Mathematics for Engineering*, which was submitted in connection with an external evaluation of the course. Comments from six other teachers in this course were also submitted.

4.4 Design of own course materials:

One of the courses which I designed and prepared from the scratch was *Informatics*, a 3 credits course for MPhil students of the Department of Fisheries and Marine Biology at the Univ. of Bergen. Otherwise, I edited and prepared materials for a number of courses including courses like *Partial Differential Equations*, *Finite Element and Domain Decomposition Methods* and *Numerical Linear Algebra*, each a 10 credits course, for undergraduate/graduate students of the Department of Mathematics and Informatics at the Univ. of Bergen.

4.5 Own pedagogical education:

I attended a short course on pedagogical education provided by the Faculty of Teacher's Education at Bergen University College.

4.9 Academic supervising experience:

4.9.1 Master in Applied and Computational Mathematics:

- *Christofer A. Elo*, UoB — Graduated, Spring 2009
  Thesis: Image denoising algorithms based on the dual formulation of TV.
  Supervision: Co-supervisor (with Aleksander Malyshev).
- *Kristian Gundersen*, UoB — Graduated, Fall 2010
  Thesis: Multiscale methods for transport equation in porous media.
  Supervision: Co-supervisor (with Jan M. Nordbotten).

4.9.2 PhD in Applied and Computational Mathematics:

- *Yunfei Ma*, Chinese Acad. Sci. — Defended, Spring 2012
  Funding: Faculty allocation from the Chinese Acad. Sci. Partially funded from the Norwegian Research Council grant received by P. Bjørstad and T. Rahman.
  Supervision: Co-supervised with Xuejun Xu (Chinese Acad. Sci.).

4.9.3 PhD in Applied and Computational Mathematics:

PhD students which I am currently supervising are as follows:

- *Atle Loneland*, UoB — Due to defend in Fall 2014
  Funding: Norwegian Research Council received by P. Bjørstad and T. Rahman.
  Responsibility: Co-supervision (with Petter Bjørstad).
- *Erik Eikeland*, UoB — Due to defend in Fall 2015
  Funding: Norwegian Research Council, received by P. Bjørstad and T. Rahman.
  Responsibility: Main-supervision (with P. Bjørstad).
- *Bin Wu*, UoB — Due to defend in Spring 2017
  Funding: R&D Bergen University College, received by T. Rahman.
  Responsibility: Main-supervision (with X.-C. Tai).

4.9.4 Postdoc in Applied and Computational Mathematics:

- *Jan Valdman*, UoB — 2008 - 2009
  In the project: Multiscale Methods.
  Supervision: Co-supervisor (with J. Nordbotten).
- *Rui Du*, UoB — Since August 2011
  In the project: Multiscale DD: Algorithms and Analysis.
  Supervision: Co-supervisor (with P. Bjørstad).

Other Assignments

5.1 Administrative assignments

5.1.2 Membership of university boards or councils:

- *Member of Steering Committee*
  DISTECH - Strategic research program at the Bergen University College.
  http://prosjekt.hib.no/distech/
- *Member of Working Group*
  PhD Program in ICT Engineering at the Bergen University College.
- *Member of Board of Trustees*
  Stamford University Bangladesh (SUB) with 14000 students (3000 are postgraduates), 300 faculty members from 16 Departments and 6 research centers.
  http://stamforduniversity.edu.bd/index.php
- *Member of Board*
  SURC - Stamford University Research Center, affiliated to the university (SUB), founded in 2009 to provide a common institutional platform for the 6 research centers.
  http://stamforduniversity.edu.bd/SURC/index.php

5.1.3 Other professional assignments of an administrative nature:

- *Member of the Board* - Fellowship for social investment, Bergen. 2009 - present
  Fellowship for social investment, Bergen (FSIB).
- *Cashier* - TU Fantoft, Bergen. 1988
- *Member* - TU Fantoft, Bergen. 1987
  TU Fantoft: Organization representing over 1200 students from Univ. of Bergen.
- *President* - Bangladeshi students union, Bergen (BSUB). 2005
  BSUB had ca. 40 Bangladeshi students as members studying at University of Bergen.
- *General Secretary* - Bangladesh association, Bergen (BAB). 1987 - 1988
  BAB had ca. 100 Bangladeshis as members living in Bergen.

A Short Resume

6.1 Name: Talal Rahman.

6.2 Year of birth: 02 November 1963.

6.3 Gender: Male.

6.4 Present position: Professor of Mathematics.

6.5 First academic degrees:

- Bangladesh: B.Engg., Electrical and Electronic, 1987, Bangladesh Univ. of Engg. Tech.
- Norway: Cand.Mag., Informatics/Numerical Analysis, 1991, Univ. of Bergen.

6.6 Doctoral degree: Dr.Scient. in Numerical Analysis, 2000, Univ. of Bergen.

6.7 Conferment of the title of professorial competence:

- Norwegian professorial competence, 03/2012, Bergen University College.
- French professorial competence, 02/2012, French Ministry of Academia and Research.

6.8 Articles in the last 6 yrs: 12 articles (refereed) + 7 articles (arXiv)

6.9 Research grants:

- FRINAT (Norwegian Ressearch Council) 2010/2015.
- DAADppp (German-Norwegian research cooperation program) 2014/2015.

6.10 Doctoral students supervised/co-supervised:

- One defended in spring 2012.
- Other three are due in 2014/2015/2017.

6.11 Pedagogical merits:

- Taught (in norwegian) several courses at undergraduate and graduate level.
- Designed and prepared materials for several courses.
- Attended a short course on pedagogical education.
- Supervised master students in applied mathematics at Univ. of Bergen.

6.12 Other information:

- Fluent in Norwegian and English. Understand Swedish.
- Permanent resident of Norway.

6.13 Web-address: www.home.hib.no/ansatte/tra/