ITN INSIST Cardiff Conference 2015

Programme

Tuesday, 15th September 2015

13:30 Tutorial - Introduction to Bayesian Learning
Frank Langbein, Cardiff University

15:00 Coffee

15:30 Session 1 (40 Minutes plus 5 minutes questions each)
Chair: Frank Langbein

ITN Course on Complexity reduction for online Computational Mechanics
Pierre Kerfriden, Cardiff University

An isogeometric boundary element method for 3D crack modeling
Xuan Peng, Cardiff University

17:00 Close

Wednesday, 16th September 2015

9:15 Coffee

9:45 Session 2 (40 Minutes plus 5 minutes questions each)
Chair: Malcolm Sabin

Quadrilateral meshes for multiply connected domains through harmonic mappings
Antonella Falini, JKU Linz

On the linear independence of hierarchical generating systems
Urška Zore, JKU Linz

Higher order and higher continuity polynomial splines over hierarchical T-meshes
Md Naim Hossain, inuTech GmbH

12:00 Lunch

13:30 Session 3 (40 Minutes plus 5 minutes questions each)
Chair: Bert Jüttler

Error bounds for homogenisation
Daniel Alves Paladim, Cardiff University

Dual-horizon peridynamics
Huilong Ren, Bauhaus-Universität Weimar

15:00 Coffee

15:30 Session 4 (40 Minutes plus 5 minutes questions each)
Chair: Pierre Kerfriden

Cartesian grid FEM for patient specific simulation
Luca Giovannelli, Universitat Politècnica de València

Remarks and discussion on the outcomes of ITN-insist
Cosmin Anitescu, Bauhaus-Universität Weimar

17:00 Close

18:30 Dinner at Shaam Nights, see attached map.

Thursday, 17th September 2015

9:15 Coffee

9:45 Session 5 (40 Minutes plus 5 minutes questions each)
Chair: Juan José Ródenas

A novel multilevel technique for image registration
Yue Jia, Bauhaus-Universität Weimar

Fast CAD feature recognition - A declarative approach
Zhibin Niu, Cardiff University

TBC

11:45 Closing remarks

12:00 Lunch

13:30 Close

Participants

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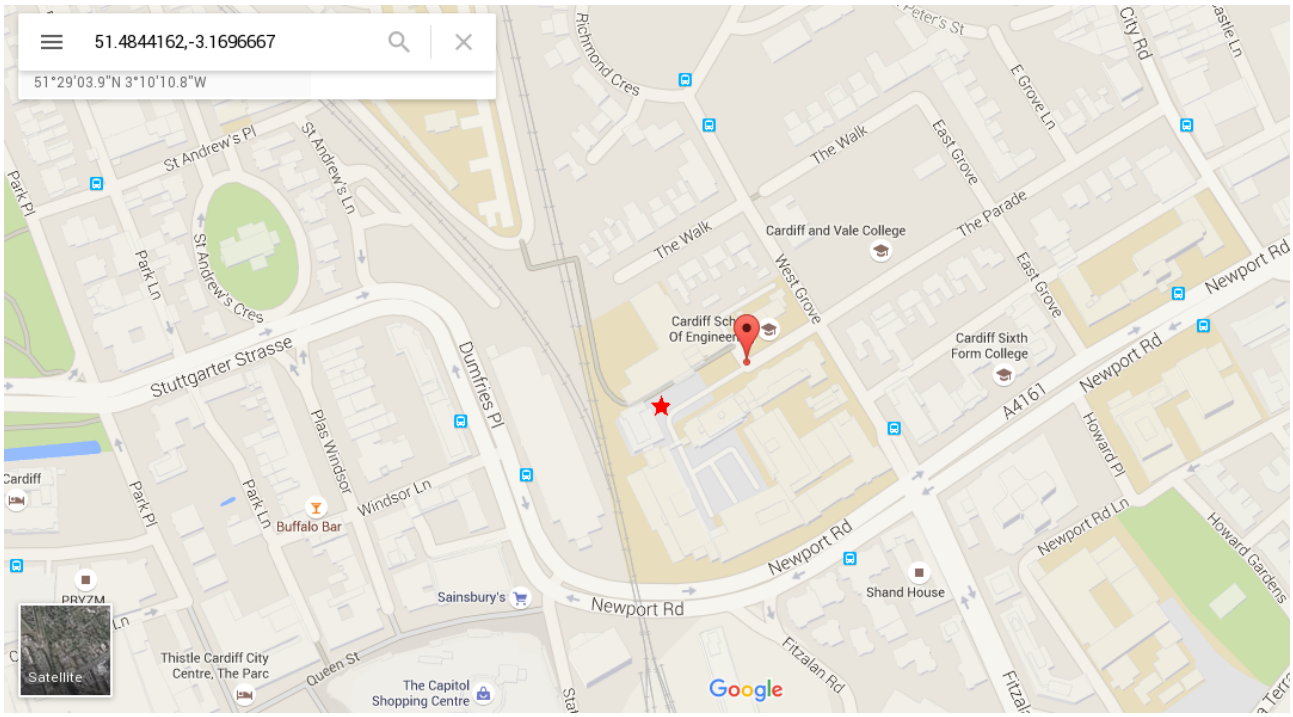
Location

Room WX/3.07 in the West Extension building of the Queen's Buildings complex, Cardiff University, 5 The Parade, Cardiff, CF24 3AA, UK.

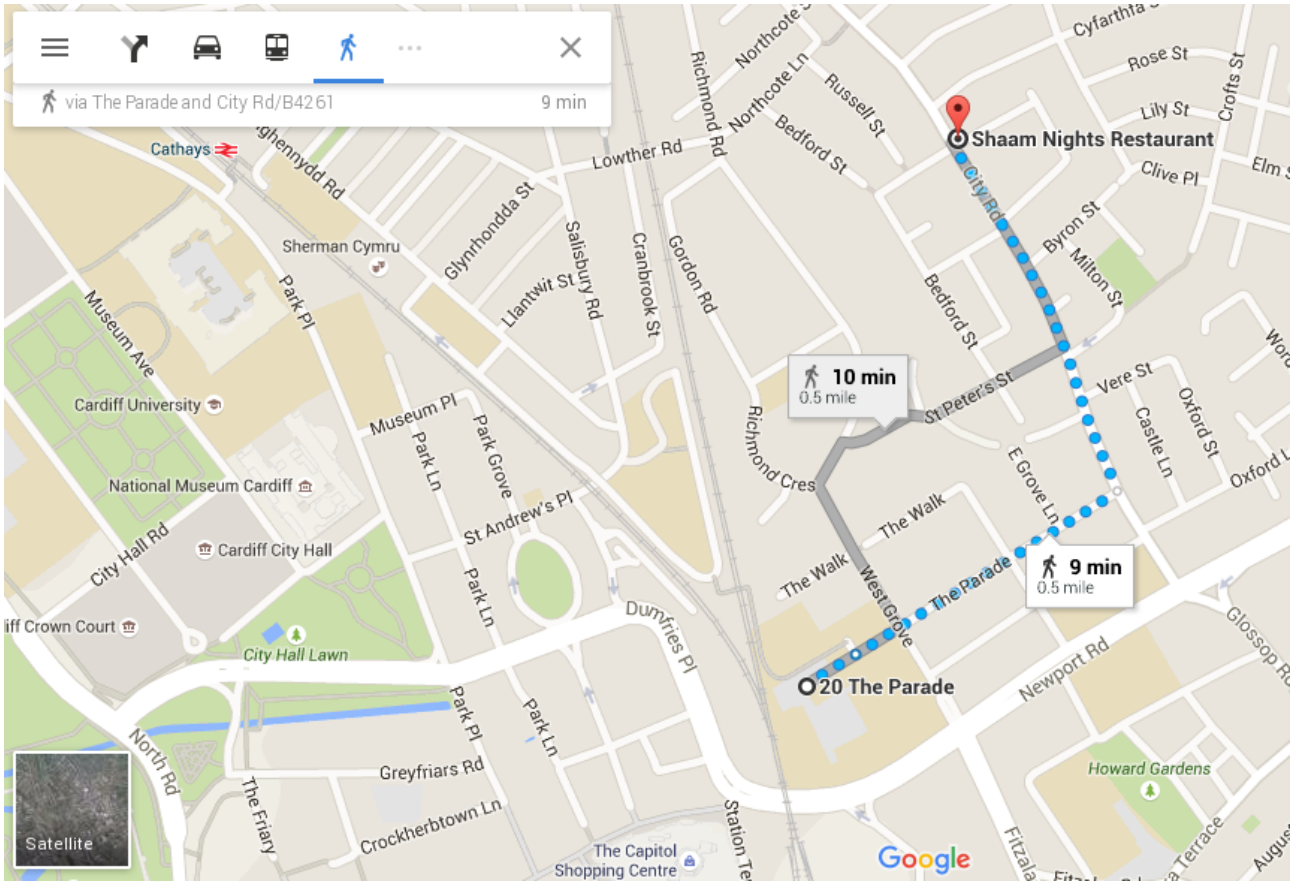


Google Maps: https://www.google.com/maps?q=51.4844162,-3.1696667

Enter the building at the doors marked with a red star on the map and go up the stairs / take the elevator to the third floor. Note, the entrance is on floor zero.

Restaurant for Dinner on 16th September 2015, 18:30

Shaam Nights, http://www.shaamnights.com/, 116-118 City Road, Cardiff, CF24 3DQ.



Abstracts

Remarks and discussion on the outcomes of ITN-insist

Cosmin Anitescu, Bauhaus-Universität Weimar

Some general remarks on the status of the project will be made. The project objectives and deliverables will be discussed, with particular reference to the research activities in Weimar. Feedback will be solicited regarding the project outcomes at the other partners.

Quadrilateral meshes for multiply connected domains through harmonic mappings

Antonella Falini, JKU Linz

Multiply connected domains of arbitrary shape can still represent a real challenge for creating good domain parameterizations by tensor-product splines, which are required in order to solve PDEs within the framework of isogeometric analysis. Our work aims at providing a segmentation of a given planar domain into patches that are topologically equivalent to quadrilaterals. These patches then can be easily parametrized by using well-known established techniques, such as Coons patches or more sophisticated optimization-based methods. The main focus of our work is therefore on the segmentation step. We construct a bijective harmonic mapping h between an input domain Ω and a reference domain $\hat{\Omega}$, which is called the template. The template is an object that possesses a multi-patch tensor-product B-spline structure. The harmonic mapping transforms the holes, which are present in the given domain, into points, in order to use existing injectivity results for harmonic mappings between multiply connected domains. Consequently, the multi-patch structure of the template also contains planar patches possessing singularities. We create an approximation of the inverse mapping h^{-1} to construct the desired segmentation by transferring the structure of the template back to the domain Ω.

Cartesian grid FEM for patient specific simulation

Luca Giovannelli, Universitat Politècnica de València

The use of Cartesian Grid FEM (CgFEM) in a patient specific framework can lighten the model preprocessing stage and make the process automatic. The creation of volumetric geometrical domains is substituted by direct meshing and heterogeneity based h-adaptivity. The method makes it possible to take into account the material local information provided by medical imaging techniques.

Higher order and higher continuity polynomial splines over hierarchical T-meshes

Md Naim Hossain, inuTech GmbH

We will describe an extension of the C^1-continuous bicubic PHT splines to handle arbitrary polynomial degrees p, and C^\alpha continuity, with p>2*alpha. The extension will be done in the framework of Geometry-Independent Field approximaTion (GIFT), which allows the use of the exact geometry mapping from a coarse NURBS mesh, without the need to recompute the control points associated to each basis function.

A novel multilevel technique for image registration
Yue Jia, Bauhaus-Universität Weimar

We present a novel dynamic multilevel technique for solving image registration problems. The development is carried out to construct a spatial transformation based on cubic B-spline basis functions and determine the control points dynamically. Unlike FEM-based image registration methods, we do not have the difficulty of solving a complicated matrix system. In addition, the presented method is enhanced by a multilevel technique, which makes it more efficient and flexible. The numerical results and several comparison studies on real bio-medical images show our technique is stable, accurate and fast, especially for large deformation registration problems.

ITN Course on Complexity reduction for online Computational Mechanics
Pierre Kerfriden, Cardiff University

Fast CAD feature recognition - A declarative approach
Zhibin Niu, Cardiff University

Automatic feature recognition aids downstream processes such as engineering analysis and manufacture. Not all features can be defined in advance; a declarative approach allows engineers to specify new features without having to design algorithms to find them. Naive translation of declarations leads to executable algorithms with high time complexity. Database queries are also expressed declaratively; there is a large literature on optimising query plans for efficient execution of database queries. Our earlier work investigated applying such technology to feature recognition, using a testbed interfacing a database system (SQLite) to a CAD modeler (CADfix). Feature declarations were translated into SQL queries which are then executed. The current work extends this approach, using the PostgreSQL database, and provides several new insights: (i) query optimisation works quite differently in these two databases (ii) with care, an approach to query translation can be devised that works well for both databases, and (iii) when finding various simple common features, linear time performance can be achieved with respect to model size, with acceptable times for real industrial models. Further results also show how lazy evaluation can be used to reduce the work performed by the CAD modeler, and how estimating the time taken to compute various geometric operations can further improve the query plan. Experimental results are presented to validate our main conclusions.

Error bounds for homogenisation
Daniel Alves Paladim, Cardiff University

In this paper, which builds on the seminal work of [1], the concept of modeling error is extended to the homogenisation of elliptic PDEs. The main difficulty is the lack of a full description of the diffusion coefficients. We overcome this obstacle by representing them as a random a field. Under this framework, it is possible to quantify the accuracy of the surrogate model (the homogenised model) in terms of first moments of the energy norm and quantities of interest. The methodology here presented rely on the Constitutive Relation Error (CRE) which states that certain measures of the primal and dual surrogate model upper bound the exact error. The surrogate model, in agreement with homogenisation, is deterministic. This property exploited to obtain bounds whose computation is also deterministic. It is also shown that minimising the CRE in the set of

homogenisation schemes leads us to an optimal surrogate that is closely related to the classical Voigt and Reuss models. Numerical examples demonstrate that the bounds are easy and affordable to compute, and useful as long as the mismatch between the diffusion coefficients of the microstructure remain small. In the case of high mismatch, extensions are proposed, through the solution of of stochastic problems.

[1] Romkes, Albert, J. Tinsley Oden, and Kumar Vemaganti. "Multi-scale goal-oriented adaptive modeling of random heterogeneous materials." Mechanics of materials 38.8 (2006): 859-872.

An isogeometric boundary element method for 3D crack modeling
Xuan Peng, Cardiff University

The isogeometric dual boundary element method (BEM) based on NURBS is adopted to model fracture problem in 3D. A stable quadrature scheme for singular integration is proposed to enhance the robustness of the method in dealing with highly distorted element. The convergence study is performed for penny-shaped crack and elliptical crack. Two ways to extract stress intensity factors, the contour M integral and virtual crack closure integral, are implemented based on the framework of isogemtric dual BEM. Compared to traditional discretization in fracture modeling, the present method gives smooth crack fronts. The fracture parameters like crack opening angles will also benefit from C1 continuity provided by the NURBS basis.

Dual-horizon peridynamics
Huilong Ren, Bauhaus-Universität Weimar

In this paper we develop a new peridynamic approach that naturally includes varying horizon sizes and completely solves the "ghost force" issue. Therefore, the concept of dual-horizon is introduced to consider the unbalanced interactions between the particles with different horizon sizes. The present formulation fulfills both the balances of linear momentum and angular momentum. Neither the "partial stress tensor" nor the "slice" technique are needed to ameliorate the ghost force issue in \cite{Silling2014}. The consistency of reaction forces is naturally fulfilled by a unified simple formulation. The method can be easily implemented to any existing peridynamics code with minimal changes. A simple adaptive refinement procedure is proposed reducing the computational cost. The method is applied to the three peridynamic formulations, namely bond based, ordinary state based and non-ordinary state based peridynamics. Both two- and three-dimensional examples including the Kalthoff-Winkler experiment and plate with branching cracks are tested to demonstrate the capability of the method in solving wave propagation, fracture and adaptive analysis .

On the linear independence of hierarchical generating systems
Urška Zore, JKU Linz

Subdivision schemes provide a simple and intuitive approach for modeling geometric objects of arbitrary topology. At the same time, certain generalizations of tensor-product splines, such as (truncated) hierarchical B--splines (THB--splines) allow for adaptive refinement in simulations based on Isogeometric Analysis.

We discuss the generalization of the THB--spline framework to spaces of functions generated by subdivision algorithms. We construct a generating system for the

corresponding multilevel space and analyze its linear independence. Since the subdivision blending functions do not possess the property of local linear independence, we need to impose certain restrictions on the domain hierarchy in order to guarantee linear independence of the hierarchical generating system.

We apply the generalized framework to spaces spanned by subdivision splines that are generated by the (modified) Butterfly subdivision scheme. In order to obtain a basis for the corresponding hierarchical space, we provide a catalog of safe subdomains that can then be used to construct a suitable domain hierarchy.