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Standard FEC Report

Document Status: With Owner
EPSRC Reference: EP/I016643/1

Scheme: Standard Research
Programme: Cross-Discipline Interface
Call/Type: Cross-discip Feas 2010 1F1541

Award Holding Organisation

Organisation	The University of Manchester	Research Organisation Reference:	R112662EMZ
Division or Department	Mathematics		

Title of Research Project

CICADA Cross-disciplinary Feasibility Account

Project Details

Start Date	01/10/2010	Duration of Grant (months)	18
End Date	31/03/2012		
Report Due Date	30/06/2012		

Funds Awarded

Summary Fund Heading	Description	Full Economic Cost	EPSRC Contribution	Percentage Contribution by EPSRC
	Funds Awarded	£ 0.00	£ 201,874.83	
Directly Incurred	Staff	£ 65,163.32	£ 52,130.65	
	Travel and Subsistence	£ 10,050.00	£ 8,040.00	
	Other Costs	£ 77,887.50	£ 62,310.00	
Exceptions	Other Costs	£ 0.00	£ 0.00	
Directly Allocated	Estate Costs	£ 20,795.46	£ 16,636.36	
Indirect Costs	Indirect Costs	£ 78,447.28	£ 62,757.82	
Exceptions	Staff	£ 0.00	£ 0.00	
Directly Allocated	Investigators	£ 0.00	£ 0.00	
	Grant Total	£ 0.00	£ 201,874.83	

Beneficiaries

We have identified five interdisciplinary research themes in the proposal. These are listed along with the academic beneficiaries. Tropical algebra of molecular processes: this proposes to develop new methods to replace simulation with analysis in certain types of complex molecular modeling, in which formation of complexes governs the dynamics. Such processes are ubiquitous in biological systems. Immediate beneficiaries will be molecular and systems biologists and computational scientists; in the long term this could have wide implications in mathematical and computational modeling.

Hybrid dynamical systems for optimizing complex industrial processes: This proposes to develop a demonstrator controller for a pilot industrial paper process which exists at University of Manchester, to show how mathematical analysis of hybrid systems can be used in real complex systems. The beneficiaries of this work will be industries which need to control industrial processes and need analytical tools to understand them, and particularly industries with safety critical issues. Academic beneficiaries will be control engineers and hybrid systems computer scientists who develop and study these systems. Models of the kinetics of human balance and falling: Goal is to develop a dynamical system model of human balance, involving both motor control and sensory input and test it against human data, in order to understand how what degradation leads to balance problems. Academic beneficiaries will be scientists of human kinetics who study human balance empirically, medical scientists who work on methods of helping humans with these problems and engineers of humanoid robotics and other engineers interesting in the real-time senso-motor processing required to balance mechanisms. Rank-order neural codes and balance: This proposes to study the information processing required to balance a humanoid or other unstable system, using spike-coupled neuron models implemented in digital hardware. Beneficiaries included robotics researchers and asynchronous hardware engineers who will learn about how to solve this task. Neuro-scientists will benefit from the existence of an implemented model which will show how a biological system could solve the problem. Hybrid dynamical systems for adaptive control in changing environments: This project will apply dynamical systems mathematics to the problem of machine learning in a dynamic environment. The issue is to make a system in which learning is robust to random or stationary variations, but responsive to changes in the environment. This is a ubiquitous problem in real-time learning systems and most approaches are heuristic. The beneficiaries will be computational scientists such as researchers in machine learning who develop algorithms for learning in drifting environments, and scientists and engineers who use these systems.

Objectives (mandatory)

The main objectives of the research [up to 4000 chars] at proposal time

The main objective of the proposal is to create an Account which supports new ideas and new collaborations which come out of CICADA research. The objectives:To provide programmers and simulators to support these projects. To provide funds to allow data collection and experiments to support the projects. To provide funds for collaborative visits. To provide funds to free up academics' time to carry out the research. To run a Creativity Workshop to augment the current research themes with one or more research themes. To explore the efficacy of the use of tropical algebra as a framework for analysing molecular process simulations (Theme 1). To build a demonstrator using hybrid systems tools developed at CICADA to control a pilot paper process plant, and determine the effectiveness (Theme 2).To build and study a mathematical model of human balance, and test it against human experiments (Theme 3).To design and test rank-order codes for designing and implementing digital neuron controllers for balancing humanoid robots (Theme 4).To explore whether dynamical systems theory can increase the efficacy of machine learning systems in dynamic environments (Theme 5).

The main objectives of the research [up to 4000 chars] at report time

Only the final two objectives were modified.

To design and test rank-order codes for designing and implementing digital neuron controllers for balancing humanoid robots and to examine ideas of control in other biological systems (Theme 4). To investigate the application of hybrid dynamics and control strategies a to the smart grids in the electricity industry (Theme 5).

Follow on Support (mandatory)

Awarding Organisation	**Application Reference**	**Title of Project**	**Decision Made**	**Award Made**	**Start Date**	**End Date**	**Amount Sought / Awarded** (£)

Grant Conditions

Investigators

Role	Name	Organisation	Division or Department	Hours/Week
Principal Investigator	Professor David Sidney Broomhead	The University of Manchester	Mathematics	0
Co-Investigator	Dr Jonathan Shapiro	The University of Manchester	Computer Science	0
Co-Investigator	Professor Nicholas Higham	The University of Manchester	Mathematics	0
Co-Investigator	Professor Paul Glendinning	The University of Manchester	Mathematics	0
Co-Investigator	Professor Howard Barringer	The University of Manchester	Computer Science	0
Co-Investigator	Professor Stephen Furber	The University of Manchester	Computer Science	0
Co-Investigator	Professor Hong Wang	The University of Manchester	Electrical and Electronic Engineering	0
Co-Investigator	Dr Martin Brown	The University of Manchester	Electrical and Electronic Engineering	0
Co-Investigator	Dr John Brooke	The University of Manchester	Research Computing Services	0
Recognised Researcher				

Patents

Details	Title	Related Grants	Authors
Reference: **Date Filed:** **Date Granted:**			

Licences, Options and Agreements

Licence Details	Business Sector	Software

Spin-Off Company

Company Name		Company House Id	Status
Details			
Nature of Business			
Sector	**Antecedents**	**Precedents**	**Associated Grant References**
Number Employees	**Employees Dates**	**Turnover**	**Turnover Date**

Academic Founders			

Other Research Outputs

Category	Details	Reference

Revenue

Please estimate the total value raised from the Intellectual Property generated through the grant (£)

0

Project Partners

Details of partners in the project and their contributions to the research.

	Organisation Details			Contact Details		
Direct contribution to project				**Indirect contribution to project**		
	Description	**Value (£)**			**Description**	**Value (£)**
Cash				Use of Facilities / Equipment		
Equipment / Materials				Staff time		
Secondment of staff				Other		
Other						
Direct contribution sub-total				Indirect contribution sub-total		
Comments on partnership						

Total Contribution from all Project Partners (£)	**0.00**

Publication Summary

	Journal	Refereed Journal	Conference Proceedings	Book	Other
Total	0	5	6	0	0
Number of Reviewed (if different from above)	0	0	0	0	0
Total with Industrial Co-Author	0	0	0	0	0
Total with International Co-Author	0	4	4	0	0

Publications

Type	Title	Author(s)	Reference				Reviewed	International Co-Author	Industrial Co-Author
			Name	Year	Vol.	Page			
Journal	Cell Death: Linear Control Analysis of Eissing's Model	-- Mark Readman -- Dimitrios Kalamatianos	MIMS Eprints	2012			No	Yes	No
Journal	A max-plus model of ribosome dynamics during mRNA translation	-- Chris Brackley -- David Broomhead -- Carmen Romano -- Marco Thiel	Journal of Theoretical Biology	2012	303	128-140	Yes	No	No
Journal	Knowledge-based Global Operation of Mineral Processing Under Uncertainty	-- Jinliang Ding -- Tianyou Chai -- Hong Wang	IEEE Transactions on Industry Informatics	2012	to appear		Yes	Yes	No
Conference	An Experimental Communication Architecture for Monitoring and Control of Sub-GRIDs	-- Zoya Pourmirza -- John Brooke	SMARTGREENS 2012	2012		67-72	Yes	No	No

Conference	Decentralized LQR Joint Servo Design for a Compliant Humanoid Robot via LMI Optimisation	-- Houman Dallali -- Gustavo Medrano-Cerda -- Martin Brown -- Nikos Tsagarakis -- Darwin Caldwell	IEEE/RSJ International Conference on Intelligent Robots and Systems	2012	to appear		Yes	Yes	No

Summary (mandatory)

The research described in simple terms in a way that it could be publicised to a general audience. [up to 4000 chars]

Revised Summary

The aim of this grant was to explore and develop new directions of research based on the research generated by CICADA (a large research project funded by EPSRC and the University of Manchester). The expected outputs were always intended to be new research proposals, and this has been the case, aided by a Creativity Workshop, although these are still in the process of submission. The research was centred on five areas (see Objectives section). Theme 1: The grant supported work on both applications and fundamental theory of max-plus algebra. Working with a group at the University of Aberdeen (Systems Biology) Prof Broomhead was able to show that ideas from max-plus algebras could be used to construct novel models of biological processes which build complex molecules such as proteins, see publications. These themes have also been worked on by Muldoon (Manchester) and Pahle (researcher), and ideas to apply these further will appear in a forthcoming Programme Grant application. As well as demonstrating the applicability of these methods, the grant supported some developments at the more abstract end of the theory, and this work forms the basis of a responsive mode grant application by Dr Kambites (Manchester) and Dr Willerton (University of Sheffield), with the working title "Tropical Modules and Categories". Theme 2: Wand and Ding worked with paper manufacturers SSK in Birmingham to understand and apply hybrid control methods to the paper industry. They used the optimization of control loops in the paper forming and the dying sections of the process to enhance water removal. Initial results have shown a potential saving of energy using this approach, with a possible new proposal to EPSRC. Theme 3: Starting from the simple hybrid model developed by the CICADA group, effort was put into understanding the role of further levels of realism (modelling muscle fatigue, more realistic control strategies) and how to extend the ideas beyond the simple problem of passive standing. Effort was put into calibrating cheap, commercially available technology (Wiis!) to allow for much more flexible experiments (standard pressure pads cost around £50K). We were successful in developing software to take data from arrays of Wii boards, and will be proposing (in the Programme Grant) to use this and our theoretical models, to examine the stability of walking up and down stairs in an ageing population. Several conference talks were given on the control aspects of this work. Theme 4: Effort was put into understanding the information needed to implement control strategies in the EPSRC-sponsored SpiNNaker hardware and associated neural models. Readman and Muldoon examined issues of control in other cell-based systems. Again, the insights and methodology obtained will form part of the next Programme Grant. Theme 5: The work on information gathering from electricity Grids will form part of bids from the University in the areas of Energy and Smart Cities (TSB Catapault competition) as part of a major cross-disciplinary initiative with industrial partners (National Grid, energy utilities) and Manchester City Council. This work will link with further projects in the analysis of such data, using mathematics from different areas, such as dynamical systems, probability and statistics. These methods are also being used to gather data from sensors in the water industry which has resulted in work with the Water Research Centre with a view to future joint bids to EPSRC and TSB in the area of water engineering. Overall: The grant has allowed us to make

sufficient progress to be confident of producing a series of well thought out grant proposals; it has also produced papers and conference contributions. The theme of noise and stochastic dynamics appeared in many applications, and we sponsored a workshop on Uncertainty Quantification to understand these issues better.

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Staff (mandatory)

Role Name	Name / Post Identifier	Duration	% FTE	Gender	Qualifications gained on project
Researcher	Houman Dallali	3	50	Male	
Researcher	Philip Bridge	2	100	Male	
Researcher	Jianling Ding	6	100	Male	
Researcher	Juergen Pahle	6	100	Male	
Researcher	Andrew Irving	1	100	Male	
Researcher	Mark Readman	2	100	Male	

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Staff Destinations (mandatory)

Name	Organisation details	Employment type
Houman Dallali	Istituto Italiano di Tecnologia (IIT). Via Morego, 30 16163 Genova, Italy Italy	HigherEducationAcademic
Philip Bridge	University of Manchester Manchester M13 9PL United Kingdom	HigherEducationAcademic
Jianling Ding	University of Manchester Manchester M13 9PL United Kingdom	HigherEducationAcademic
Juergen Pahle	Modeling and Simulation Group, Saarland University Campus E1.7, 66123 Saarbrücken Germany	HigherEducationAcademic
Andrew Irving	Organisation Not Given United Kingdom	NotEmployed
Mark Readman	University of Manchester Manchester M13 9PL United Kingdom	HigherEducationAcademic

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