FCT Fundação para a Ciência e a Tecnologia

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Concursos de Projectos de I&D
Calls for R&D Projects

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Visão global da candidatura
Application overview

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Referência do projecto
Project reference
PTDC/EEA-EEL/104278/2008

1. Identificação do projecto
1. Project description -

Área científica principal
Main Area
Engenharia Electrotécnica - Energia Eléctrica

Área científica Secundária
Secondary area
(Vazio)
(Void)

Título do projecto (em português)
Project title (in portuguese)
LASCA - Uso de Autocodificadores em Problemas de Grande Dimensão - Aplicação a Sistemas de Potência

Título do projecto (em inglês)
Project title (in english)
LASCA - Large Scale Computing with Autoencoders - Application to Power Systems

Financiamento solicitado
Requested funding
138.642,00€

Palavra-chave 1
Sistemas de Energia

Palavra-chave 2
Problemas de Grande Dimensão

Palavra-chave 3
Redes Neuronais

Palavra-chave 4
Computação Evolucionária

Keyword 1
Power Systems

Keyword 2
Large Scale Problems

Keyword 3
Neural Networks

Keyword 4
Evolutionary Computing

Data de início do projecto
Starting date
01-10-2009

Duração do projecto em meses
Duration in months
30

2. Instituições envolvidas
2. Institutions and their roles

Instituição Proponente
Principal Contractor
Instituto de Engenharia de Sistemas e Computadores do Porto (INESC Porto/FE/UP)
Campus da FEUP - Rua Dr. Roberto Frias, 378
4200-465Porto

Instituição Participante
Participating Institution
(Vazio)
(Void)

Unidade de Investigação
Research Unit
Instituto de Engenharia de Sistemas e Computadores do Porto (INESC Porto/FE/UP)
Campus da FEUP - Rua Dr. Roberto Frias, 378
4200-465Porto

Unidade de Investigação Adicional
Additional Research Unit
(Vazio)
(Void)

Instituição de Acolhimento
Host Institution
Instituto de Engenharia de Sistemas e Computadores do Porto (INESC Porto/FE/UP)
Campus da FEUP - Rua Dr. Roberto Frias, 378
4200-465Porto

3. Componente Científica
3. Scientific Component

3.1. Sumário
3.1 Summary

3.1.a Sumário Executivo (em português)
3.1.a Executive Summary (in Portuguese)

O projecto LASCA visa explorar as propriedades de redes neuronais especiais designadas "autocodificadores" para auxiliar a resolução de problemas de grande dimensão em Sistemas de Energia. Os autocodificadores foram propostos para problemas de compressão de imagem, por exemplo, mas não há registo de outro uso significativo.

Uma das novas ideias a ser explorada neste projecto é a de que os autocodificadores condensam informação num espaço de reduzida dimensão e isto pode ser usado para reduzir o fardo computacional que uma meta-heurística de optimização (como comptação evolucionária) implica, pois é conhecido que este métodos são grandes consumidores de recursos informáticos em problemas de grande dimensão.

Um teste preliminar num problema de coordenação hidro-térmica (uma tese de Mestrado com um artigo submetido a um jornal internacional) permite confiar que, em alguns tipos de problemas, uma importante aceleração da computação das soluções possa ser conseguida (até 16 vezes, em casos experimentados).

O projecto visa identificar um (reduzido) número de problemas na área dos Sistemas de Energia que possam servir de bancada de teste sobre a utilidade da adopção do conceito dos autocodificadores. Estes problemas serão caracterizados e um modelo conveniente será desenvolvido para cada caso, permitindo comparações com um procedimento convencional de solução.

Porque esta é uma ideia original, é admissível que um certo número de artigos possa ser submetido e publicado. Da mesma forma, o projecto tem substância que poderá aproveitar a teses de doutoramento, mas haverá que ser prudente neste matéria pois a duração do projecto é mais curta que a normal duração da elaboração de uma tese.

3.1.b Sumário Executivo (em inglês)
3.1.b Executive Summary (in English)

Project LASCA aims at exploring the properties of special neural networks denoted as "autoencoders" in helping to solve a number of

large scale problems in Power Systems. Autoencoders have been used for image compression, for instance, but no other significant use has been reported.

One of the new ideas to be explored in the project is that
autoencoders condense information in a space of reduced dimension and this may be used to reduce the computational burden imposed on meta-heuristics (such as evolutionary algorithms), which are known to consume large computing resources in large scale problems.

A preliminary test with a wind-hydro coordination problem (a MSc thesis with a paper submitted to publication) allowed one to expect, in some types of problems, an important speed-up in the solving of optimization problems (up to 16 times in the tested cases).

The project aims at identifying a (reduced) number of suitable problems in the Power Systems area that may put to test the usefulness of adopting the concept of autoencoders. These problems will be characterized and then a convenient model will be developed in each case and comparisons made with a conventional solution procedure.

Because this is an original idea, a number of papers are likely to be submitted and published. Also, there is material in the project to give contributions to PhD theses, but one must be cautious in this respect because the duration of the project is shorter than the average duration of a PhD thesis work.

3.2. Descrição Técnica
3.2 Technical Description

3.2.1. Revisão da Literatura
3.2.1. Literature Review

Project LASCA proposes an original idea - autoencoders - with a high potential impact in the efficiency of the optimization of many real problems in Power Systems.

It is a known mathematical property of real valued spaces that it is possible to define functions that establish a one-to-one mapping between points of a space of dimension m and a space of dimension n (with $n < m$ without loss of generality). The theorems supporting this assertion, however, do not indicate how to construct such functions.

An approximation may however be achievable through the use of a space reduction technique known as autoencoders, which are feedforward neural networks that are trained to reproduce the input space S in the output. If an inner layer has a reduced number of neurons n compared to the set of m inputs/outputs, this layer will effectively be encoding variables from S into a smaller dimension space S'. The number of layers in the autoencoder neural network may be critical to this process, and it has been argued that it is similar to Principal Component Analysis [1] but where one has non-linear projections in a non-linear manifold.

Feature reduction and feature selection techniques have been used to reduce the number of variables of a problem to a set of meaningful ones. One popular technique is PCA. This technique projects the data into a linear subspace with minimum information loss, by multiplying the data by the eigenvectors of the sample covariance matrix. A point is then represented by its coordinates along the directions of greatest variance in the data set.

However, when one is optimizing and one needs to evaluate solutions during the process, a feature reduction or selection process is not applicable because some or all variable values of the original space would be unknown and therefore the actual value of the objective function could not be calculated.

The concept of autoencoders has been proposed in the past [2][3] with the purpose of using the reduced encoded values in S' (the reduced dimension space of the inner layer of the autoencoder) to represent images in a compressed way, so that this representation would be subject then to distinct processing techniques such as identification and pattern recognition. For instance, face images could be identified and clustered according to sex, distinguished from non faces, etc [4].

The first half of the neural network approximates the function that maps the input space to the space of compressed encoding S' while the second half approximates the inverse function. The quality of this encoding and decoding process depends on the quality of the training.

It has been found that it was much more difficult to optimize the weights in autoencoders with non-linear activation functions and multiple layers than with a single hidden layer and recent efforts were concentrated in devising schemes to achieve a more efficient training [5].

To the date, no publication has been found that would profit from the space reduction offered by an autoencoder to benefit the performance of optimization algorithms. This an original idea of the PI (Principal Investigator), emerging from a previous FCT project (EPSO - POSC/EEA-ESE/60980/2004) and resulting in a MSc. Thesis [6] and a paper submitted to the IEEE Transactions in Power Systems [7]. In this paper, a speed up of 16 times has been detected for a space size reduction from 336 variables to 168 variables in a wind-hydro coordination problem. This paper (confidential) is attached to this project proposal as an annexed document.

The technique will be used in conjunction with EPSO - Evolutionary Particle Swarm Optimization algorithms, to perform optimization.

EPSO algorithms have been developed in the project referred to above and have proved to be valuable tools with very competitive features [8][9]. The results in paper [7], though extremely encouraging, are however just preliminary and just open the way to the development of a new concept.

LASCA will focus on the coupling of autoencoders with evolutionary algorithms, but other applications of autoencoders in power systems problems will be explored, profiting from the experience obtained in the work. One of these properties allows one to use autoencoders to the restoration of missing sensor signals[10]. There are no known applications of autoencoders to Power Systems.

[1] Jolliffe I.T., “Principal Component Analysis”, Springer Series in Statistics, Springer, NY, 2002
[2] G.W. Cottrell, P. Munro and D. Zipser, “Learning internal representations from gray-scale images: An example of extensional programming”, Proceedings of the Ninth Annual Conference of the Cognitive Science Society, Seattle (WA), USA, 1987
[3] M.K. Fleming, G.W. Cottrell, “Categorization of faces using unsupervised feature extraction”, Proceedings of IJCNN - International Joint Conference on Neural Networks, vol. 2, pp. 65-70, San Diego (CA), USA, 17-21 Jun 1990
[4]B. Golomb and T. Sejnowski, “Sex Recognition from Faces Using Neural Networks”, in A. Murray (ed.), “Applications of Neural Networks”, pp. 71-92, Kluwer Academic Publishers, 1995
[5] G. E. Hinton and R. R. Salakhutdinov, “Reducing the Dimensionality of Data with Neural Networks”, Science, Vol. 313, no. 5786, pp. 504 – 507, July 2006
[6] Luís Costa, "Application of Evolutionary Swarms and Autoencoders to Wind-Hydro coordination", MSc. Thesis in Electrical Engineering and Computing, FEUP (University of Porto, July 2008
[7] V. Miranda and L. Costa, "Wind-hydro coordination using autoencoders to perform space dimension reduction and speed up evolutionary processes", submitted to IEEE Transactions in Power Systems, 2008 (in reviewing process).
[8] V. Miranda, H. Keko and A. Jaramillo,“EPSO: Evolutionary Particle Swarms”, Ch. 6 in “Advances in Evolutionary Computing for System Design”, L. Jain et al. Eds., Springer, series: Studies In Computational Intelligence, ISBN 978-3-540-72376-9, Volume 66, pp. 139-168, 2007.
[9] Vladimiro Miranda, Hrvoje Keko and Álvaro Jaramillo Duque, “Stochastic Star Communication Topology in Evolutionary Particle Swarms (EPSO)”, Int. J. of Comp. Intelligence Research, no.2, 2008.
[10] Thompson, B.B.; Marks, R.J., II; El-Sharkawi, M.A., "On the contractive nature of autoencoders: application to missing sensor restoration", Proceedings of the International Joint Conference on Neural Networks, Volume 4, Issue , 20-24 July 2003 Page(s): 3011 - 3016.

3.2.2. Plano e Métodos

3.2.2. Plan and Methods

Project LASCA proposes an original idea - autoencoders - with a high potential impact in the efficiency of the optimization of many real problems in Power Systems. This is the main core of the project.
An autoencoder is a neural network with input and output layers of the same size, and with an inner layer of a smaller dimension, and trained such that the output reproduces the input. When this training is successful, one may say that the information content of the data set has been compressed (reduced in space dimension), becase the signals in the inner (narrower) layer must contain all the information necessary to allow the network to recompose the input information at the output layer.
The original idea to be tested and developed in the project is to apply an autoencoder to a large scale optimization problem, to be solved by an evolutionary algorithm, and to run this algorithm over the (inner) reduced space variables (defined by the signals in the inner layer) instead of the (outer) original decision space. The variables in the inner space have no physical meaning but nevertheless encode the information of the decision space.
However, this scheme is only feasible is the evaluation of each solution is possible - this becomes assured by the second half of the autoencoder. If a solution from the inner space can be mapped into a real world solution, then evaluation becomes possible - and, therefore, evolutionary operators like selection as well as penalties may be readily applied.

If this strategy is feasible, then the evolutionary process will search and evolve in a space of reduced dimension. It is well known that evolutionary algorithms show poor performance in problems of high dimension or take too much time to converge, if they converge at all. Being able to consistently reduce the dimension of the search space my establishihg a 1-to-1 mapping between two spaces of different dimensions will therefore be a major step into solving real world problems.

The main problems to be dealt with in LASCA are:
1. How to effectively train an autoencoder for this optimization purpose?
2. What is the influence of the architecture of the autoencoder in the optimization efficiency?
3. What is the relation between the more or less deceptive character of the "landscape" (optimization surface) and the requirements for the definition of type and arquitecture of the autoencoder?
4. What are the convenient strategies to produce an efficient hybrid of an evolutionary algorithm with autoencoders to maximize efficiency of use?
5. How to effectively deal with constraints in an autoencoder?
6. Should one encode also the objective function value?
7. Are Power Systems problems included in the class of problems that auto-encoders help to solve?
8. Can the properties of autoencoders be directly used to solve some Power System problems not only inside an optimization iterative process but also by externally treating data?
9. What is the performance gain obtained and expectable on average?
10. How to deal with an imperfect mapping? How to deal with the input vs. output error?

The success in the project constitutes a real advancement in the state of the art in solving large scale optimization problems with meta-heuristics - the reason being that it is well known that meta-heuristics, namely of the evolutionary type, converge very slowly for problems with a large number of variables (in the order of hundreds or thousands). A problem with 500 variables, in an EPSO

algorithm with 100 particles, will require 200.000 objective function evaluations to run for 1000 generations. Because the evaluation task is in general very time consuming in complex Power System problems (for instance, requiring each time an OPF - optimal power flow to be run) this places a terrible burden in computing time and hours may be required in good performing machines. If autoencoders prove successful in reducing this effort by a scale of 10, this will have a direct impact in the feasibility of the use of models in industrial applications.

The project will use the best results and developments from the previous project EPSO (POSC/EEA-ESE/60980/2004), especially the software developed in C++. This software will not only be adopted as the main evolutionary algorithm for test purposes but also in the attempt to develop efficient forms to train the autoencoders, as an alternative to backpropagation algorithms. Information about EPSO may be found in http://epso.inescporto.pt.

In section 3.4. of this proposal (Paste Publications) one lists 5 papers that contain material or demonstrate a team experience relevant to the proposed research. All these papers are included in pdf format as attached documents to this proposal.

The project will therefore be split into to task streams, one devoted to more generic research on autoencoders and another devoted to tests in selected Power System problems. Subject to revision during the project, one envisions the following problems to become possible tests for the autoencoder application:
a) the wind-hydro-thermal coordination problem in operation planning
b) the unit commitment problem
c) the transmission expansion planning problem

All these problems are large scale problems for real systems because they must be solved not only for the basic physical variables but also along the time domain, usually discretized into time steps.

One of the activities of the project, therefore, will be to implement ot build up adequate software applications that may solve the selected problems, so that the autoencoder strategy may be tested. This is a time consuming and demanding task justifying considerable effort.

A number of complex models need to be programmed in a careful way so that a fair comparison may be established between the classical algorithms and the autoencoder strategy. All these models (such as the examples referred to above) are complex and demanding in computing effort. The labour involved in the project will therefore be considerable. As a large numer of experiments for applications that are likely to have run durations in the order of magnitude of hours, if solved in a regular computer, one envisions to acquire a very fast workstation that may allow the speed up of computations and this is felt as a critical condition to allow success to the project.

The final results of the project will be:
1. A methodology to include autoencoders in evolutionary optimization processes
2. A software platform
3. New and more efficient models to solve selectd Power System problems
4. Papers submitted and published in international conferences and journals
5. Contributions to PhD and MSc. theses

3.2.3. Tarefas
3.2.3. Tasks

Lista de tarefas (7)
Task list (7)

Designação da tarefa Task denomination	**Data de início** Start date	**Data de fim** End date	**Pessoas * mês** Person * months
State of the art in autoencoders	01-10-2009	30-06-2010	5
Training autoencoders	01-01-2010	31-10-2010	10
Software platform development	01-01-2010	31-12-2011	20
Hybrids autoencoder-EPSO	01-06-2010	31-05-2011	10
Tests in real world large scale Power Sy...	01-06-2010	30-11-2011	20
Dissemination	01-10-2010	31-03-2012	4
Final report	01-12-2011	31-03-2012	3

(Os detalhes de cada tarefa estão disponíveis clicando na designação correspondente)
(Details for each task are available by clicking on the corresponding denomination)

3.2.4. Calendarização e Gestão do Projecto
3.2.4. Project Timeline and Management

3.2.4.a Descrição da Estrutura de Gestão
3.2.4.a Description of the Management Structure

The management structure is simple because the project involves only one institution and a reduced number of researchers,

The Principal Investigator will coordinate all activities and define an agenda of meetings to ensure the proper conduction of the process.

3.2.4.b Lista de Milestones

3.2.4.b Milestone List

Data	**Designação da milestone**
Date	Milestone denomination
30-09-2010	State of the art

Descrição

Description

This milestone marks the end of the learning phase and the begining of the development of the final software platform and tests in real problems.

Data	**Designação da milestone**
Date	Milestone denomination
30-06-2011	Conceptual phase ended

Descrição

Description

This milestone marks the end of the tasks where the more fundamental and conceptual develpoments will take place

3.2.4.c Cronograma

3.2.4.c Timeline

Ficheiro com a designação "timeline.pdf", no 9. Ficheiros Anexos, desta Visão Global (caso exista).

File with the name "timeline.pdf" at 9. Attachments (if exists).

3.3. Referências Bibliográficas

3.3. Bibliographic References

Referência Reference	**Ano** Year	**Publicação** Publication
[1]	2002	Jolliffe I.T., “Principal Component Analysis”, Springer Series in Statistics, Sp ringer, NY, 2002
[2]	1987	G.W. Cottrell, P. Munro and D. Zipser, “Learning internal representations from g ray-scale images: An example of extensional programming”, Proceedings of the Nin th Annual Conference of the Cognitive Science Society, Seattle (WA), USA, 1987
[3]	1990	M.K. Fleming, G.W. Cottrell, “Categorization of faces using unsupervised feature extraction”, Proceedings of IJCNN - International Joint Conference on Neural Ne tworks, vol. 2, pp. 65-70, San Diego (CA), USA, 17-21 Jun 1990
[4]	1995	B. Golomb and T. Sejnowski, “Sex Recognition from Faces Using Neural Networks”, in A. Murray (ed.), “Applications of Neural Networks”, pp. 71-92, Kluwer Academi c Publishers, 1995
[5]	2006	G. E. Hinton and R. R. Salakhutdinov, “Reducing the Dimensionality of Data with Neural Networks”, Science, Vol. 313, no. 5786, pp. 504 – 507, July 2006
[6]	2008	Luís Costa, "Application of Evolutionary Swarms and Autoencoders to Wind-Hydro c oordination", MSc. Thesis in Electrical Engineering and Computing, FEUP (Univers ity of Porto, July 2008
[7]	2008	V. Miranda and L. Costa, "Wind-hydro coordination using autoencoders to perform space dimension reduction and speed up evolutionary processes", submitted to IEE E Transactions in Power Systems, 2008 (in reviewing process).
[8]	2008	V. Miranda, H. Keko and A. Jaramillo,“EPSO: Evolutionary Particle Swarms”, Ch. 6 in “Advances in Evolutionary Computing for System Design”, L. Jain et al. Eds., Springer, series: Studies In Computational Intelligence, ISBN 978-3-540-72376-9 , Volume 66, pp. 139-168, 2007.
[9]	2008	Vladimiro Miranda, Hrvoje Keko and Álvaro Jaramillo Duque, “Stochastic Star Comm unication Topology in Evolutionary Particle Swarms (EPSO)”, Int. J. of Comp. Int elligence Research, no.2, 2008
[10]	2003	Thompson, B.B.; Marks, R.J., II; El-Sharkawi, M.A., "On the contractive nature o f autoencoders: application to missing sensor restoration", Proceedings of the I nternational Joint Conference on Neural Networks, Volume 4, Issue , 20-24 July 2 003 Page(s): 3011 - 3016

3.4. Publicações Anteriores

3.4. Past Publications

Referência Reference	**Ano** Year	**Publicação** Publication

A	2008	Vladimiro Miranda, Hrvoje Keko and Álvaro Jaramillo Duque, “Stochastic Star Communication Topology in Evolutionary Particle Swarms (EPSO)”, Int. J. of Comp. Intelligence Research, no.2, 2008
B	2007	Armando M. Leite da Silva, Leónidas Resende, Luiz Antônio Manso, Vladimiro Miranda, “Composite Reliability Assessment Based on Monte Carlo Simulation and Artificial Neural Networks”, IEEE Transactions on Power Systems, vol.22, no.3, pp.1202-1209, Aug 2007.
C	2007	H. Keko , A. Jaramillo Duque , Vladimiro Miranda, "A Multiple Scenario Security Constrained Reactive Power Planning Tool Using EPSO", International Journal of Engineering Intelligent Systems, vol. 15, no. 2, June 2007
D	2005	Adriana Rosa Garcez Castro, Vladimiro Miranda, “Knowledge Discovery in Neural Networks with Application to Transformer Failure Diagnosis”, IEEE Transactions on Power Systems, Vol. 20, no.2, pag. 717-724, May 2005
E	2007	V. Miranda, H. Keko and A. Jaramillo, “EPSO: Evolutionary Particle Swarms”, Ch. 6 in “Advances in Evolutionary Computing for System Design”, L. Jain, V. Palade, D. Srinivasan Eds., Springer, series: Studies In Computational Intelligence, ISBN 978-3-540-72376-9, Volume 66, pp. 139-168, 2007.

4. Equipa de investigação
4. Research team

4.1 Lista de membros
4.1. Members list

Nome Name	Função Role	Grau académico Academic degree	%tempo %time	CV nuclear Core CV
Vladimiro Henrique Barrosa Pinto Mira...	Inv. Responsável	DOUTORAMENTO	25	✓

(O curriculum vitae de cada membro da equipa está disponível clicando no nome correspondente)
(Curriculum vitae for each research team member is available by clicking on the corresponding name)
Total: 1

4.2. Lista de membros a contratar durante a execução do projecto
4.2. Members list to hire during project"s execution

Membro da equipa Team member	Função Role	Duração Duration	%tempo %time
(BI) Bolseiro de Investigação (Mestre) 1	Bolseiro	24	100
(BI) Bolseiro de Investigação (Mestre) 2	Bolseiro	24	100
(BPD) Bolseiro de Pós-Doutoramento 1	Bolseiro	12	100

Total: 3

5. Projectos financiados
5. Funded projects

Lista de projectos financiados
Funded projects list

Referência Reference	Título Title	Estado Status
POSC/EEA-ESE/60980/2004	EPSO - Enxame de Partículas Ev...	Concluído

(Os detalhes de cada projectos estão disponíveis clicando na referência correspondente)
(Details for each project are available by clicking on the corresponding reference)
Total: 1

6. Indicadores previstos
6. Expected indicators

Indicadores de realização previstos para o projecto
Expected output indicators

Descrição Description	2009	2010	2011	2012	2013	Total
A - Publicações Publications						
Livros Books	0	0	0	0	0	**0**

Artigos em revistas internacionais Papers in international journals	0	2	2	0	0	**4**
Artigos em revistas nacionais Papers in national journals	0	0	0	0	0	**0**
B - Comunicações Communications						
Comunicações em encontros científicos internacionais Communications in international meetings	0	2	3	1	0	**6**
Comunicações em encontros científicos nacionais Communications in national meetings	0	0	0	0	0	**0**
C - Relatórios Reports	0	1	0	1	0	**2**
D - Organização de seminários e conferências Organization of seminars and conferences	0	0	0	0	0	**0**
E - Formação avançada Advanced training						
Teses de Doutoramento PhD theses	0	0	0	1	0	**1**
Teses de Mestrado Master theses	0	1	1	0	0	**2**
Outras Others	0	0	0	0	0	**0**
F - Modelos Models	0	0	0	1	0	**1**
G - Aplicações computacionais Software	0	0	0	1	0	**1**
H - Instalações piloto Pilot plants	0	0	0	0	0	**0**
I - Protótipos laboratoriais Prototypes	0	0	0	0	0	**0**
J - Patentes Patents	0	0	0	0	0	**0**
L - Outros Other						
	0	0	0	0	0	**0**
	0	0	0	0	0	**0**
	0	0	0	0	0	**0**

Acções de divulgação da actividade científica
Scientific activity spreading actions

A web site will be put up to disseminate the results of ythe project and especially to highlight the industrial application.

7. Orçamento
7. Budget

-

Instituição Proponente
Principal Contractor

Instituto de Engenharia de Sistemas e Computadores do Porto

Descrição Description	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Recursos Humanos Human resources	0,00	22.395,00	40.665,00	7.975,00	0,00	**71.035,00**
Missões Missions	0,00	6.750,00	9.000,00	2.250,00	0,00	**18.000,00**
Consultores Consultants	0,00	5.000,00	5.000,00	0,00	0,00	**10.000,00**
Aquisição de bens e serviços Service procurement and acquisitions	0,00	500,00	500,00	500,00	0,00	**1.500,00**
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Gastos gerais	3.000,00	6.929,00	11.033,00	2.145,00	0,00	**23.107,00**

Overheads						
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	**3.000,00**	**41.574,00**	**66.198,00**	**12.870,00**	**0,00**	**123.642,00**
Equipamento Equipment	15.000,00	0,00	0,00	0,00	0,00	**15.000,00**
Total	**18.000,00**	**41.574,00**	**66.198,00**	**12.870,00**	**0,00**	**138.642,00**

Instituições Participantes

Participating Institutions

(Não se encontram registadas Instituições Participantes para este projecto)
(No Participating Institution has been registered for this project)

Orçamento Global

Global budget

Descrição Description	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Recursos Humanos Human resources	0,00	22.395,00	40.665,00	7.975,00	0,00	**71.035,00**
Missões Missions	0,00	6.750,00	9.000,00	2.250,00	0,00	**18.000,00**
Consultores Consultants	0,00	5.000,00	5.000,00	0,00	0,00	**10.000,00**
Aquisição de bens e serviços Service procurement and acquisitions	0,00	500,00	500,00	500,00	0,00	**1.500,00**
Registo de patentes Patent registration	0,00	0,00	0,00	0,00	0,00	**0,00**
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0,00	0,00	0,00	0,00	0,00	**0,00**
Gastos gerais Overheads	3.000,00	6.929,00	11.033,00	2.145,00	0,00	**23.107,00**
TOTAL DESPESAS CORRENTES TOTAL CURRENT EXPENSES	**3.000,00**	**41.574,00**	**66.198,00**	**12.870,00**	**0,00**	**123.642,00**
Equipamento Equipment	15.000,00	0,00	0,00	0,00	0,00	**15.000,00**
Total	**18.000,00**	**41.574,00**	**66.198,00**	**12.870,00**	**0,00**	**138.642,00**

Plano de financiamento

Finance plan

Descrição Description	**2009**	**2010**	**2011**	**2012**	**2013**	**Total**
Financiamento solicitado à FCT Requested funding	18.000,00	41.574,00	66.198,00	12.870,00	0,00	**138.642,00**
Financiamento próprio Own funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Outro financiamento público Other public-sector funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Outro financiamento privado Other private funding	0,00	0,00	0,00	0,00	0,00	**0,00**
Total do Projecto Total of the project	**18.000,00**	**41.574,00**	**66.198,00**	**12.870,00**	**0,00**	**138.642,00**

8. Justificação do orçamento

8. Budget rationale

-

8.1. Justificação dos recursos humanos

8.1. Human resources rationale

Tipo Type		**Nº de pessoas** No. of persons
(BI) Bolsa de Investigação (Mestre)		2
Duração (em meses) Duration (in months)	**Custo envolvido (€) *(calculado)*** Total cost (€) *(estimated)*	**Outros custos (€)** Other costs (€)
24	47.040,00	4.230,00

Justificação do financiamento solicitado
Rationale for requested funding

Two researchers with a MSc degree in Computing and/or in Power Systems will be required: each for 24 months. They will be the main labour force in terms of software development and real world power system problem testing. One will enter 3 months before the other.

One foresees also the inclusion of other researchers at INESC Porto, for limited periods of time, especially in the task of "Tests in real problems", to profit from occasional real problems available at the moment in the research Unit.

Tipo
Type
(BPD) Bolsa de Pós-Doutoramento

Nº de pessoas
No. of persons
1

Duração (em meses)
Duration (in months)
12

Custo envolvido (€) *(calculado)*
Total cost (€) *(estimated)*
17.940,00

Outros custos (€)
Other costs (€)
1.825,00

Justificação do financiamento solicitado
Rationale for requested funding

1 Post-doc researcher to help in the supervision of the applications of the method to real Power System problems and to assist the PI in the development of theoretical models explainig the behavior of the method in terms of performance and convergence.

This researcher will be admitted 6 months after the beginning of the project.

8.2. Justificação de missões
8.2. Missions rationale

Tipo
Type
Outro (other)

Nº de deslocações
No. of participations
2

Local
Venue
United States

Custo envolvido (€)
Cost (€)
4.500,00

Justificação do financiamento solicitado
Rationale for requested funding

Traveling to meet and work with the consultant Prof. Mohamed El-Sharkawi at the University of Washington, once a year (2010 and 2011)

Tipo
Type
Participação em congressos

Nº de deslocações
No. of participations
6

Local
Venue
United States, Europe, Brasil

Custo envolvido (€)
Cost (€)
13.500,00

Justificação do financiamento solicitado
Rationale for requested funding

Estimated an average of 1000 Euros per return flight and other travelling means (trains, car rental especially in the US), 500 Euros per registration and 150 Euros per day for lodging and subsistence x 5 days each

8.3. Justificação de consultores
8.3. Consultants rationale

Nome completo
Full name
Mohamed El-Sharkawi

Instituição
Institution
University of Washington

Fase do projecto
Project phase
All development tasks

Custo (€)
Cost (€)
10.000,00

Justificação do financiamento solicitado
Rationale for requested funding

Prof. El-Sharkawi is a IEEE Fellow with expertise in Power Systems and applications of neural networks. He also published works in autoencoders (ref. [10]). One plans to involve him an equivalent of 2 weeks per year and support travelling and lodging from Seattle to Porto.
CV: https://www.ee.washington.edu/people/faculty/elsharkawi/

Página na Internet onde pode ser consultado o CV do consultor

Web page where the consultant's CV can be accessed

https://www.ee.washington.edu/people/faculty/elsha...

8.4. Justificação de aquisição de bens e serviços

8.4. Service procurement and acquisitions

Tipo Type	Custo (€) Cost (€)
a diversity of items	1.500,00

Justificação do financiamento solicitado

Rationale for requested funding

Communications, computer maintenance, etc.

8.6. Justificação do Equipamento

8.6. Equipment rationale

8.6.1. Equipamento já disponível para a execução do projecto

8.6.1 Available equipment

(Vazio)
(Void)

8.6.2. Discriminação do equipamento a adquirir

8.6.2. New equipment requested

Tipo de equipamento Equipment type	Fabricante Manufacturer	Modelo Model	Custo (€) Cost (€)
Computers	to be selected	to be selected	15.000,00

Justificação do financiamento solicitado

Rationale for requested funding

One will require 3 computers (laptop type + docking station, according to INESC Porto/USE policy) to the working posts of the 3 researchers that will be added to the project (2 at MSc level and 1 Post-doc). These will be purchased with extra batteries to allow extended autonomy, and accessories to allow remote work (namely when travelling).
One will require 1 Quad-core high performance workstation type HP 8600 or similar to be shared in the network and allow heavy computing. Flat screen monitors will be acquired. Equipment will be purchased in an early phase of the project.

8.7. Justificação de registo de patentes

8.7. Patent registration

(Vazio)
(Void)

8.8. Justificação de adaptação de edifícios e instalações

8.8. Adaptation of buildings and facilities

(Vazio)
(Void)

9. Ficheiros Anexos

9. Attachments

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Nome Name	Tamanho Size
CRL Eng Int Sys 2008.pdf	512Kb
EPSO CHAPTER Miranda Corrected Version.pdf	267Kb
ijcir2007_artigo_Revised Final.pdf	205Kb
Paper_TPWRS-00878-R1.pdf	182Kb
Publicado IEEE PWRS Adriana.pdf	351Kb
timeline.pdf	53Kb
Tr 2008 LCosta B mir subm.pdf	238Kb

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