**Call for Exploratory Projects in All Scientific Domains 2023**
2023.15110.PEX

Status
**Draft**

Closes in
**01.03.202**

# Application Global View

## General data

**Principal investigator**

Francisco Manuel Gonçalves Coelho

**Project title in portuguese**

Indução de Stochastic Answer Set Programs por Meios Algébricos

**Project title in english**

Induction of Stochastic Answer Set Programs by Algebraic Means

**Project acronym**

IsaSpam

**Keywords in portuguese**

Indução de Programas Lógicos  Programação Lógico-Probabilística  Programação de Conjunto de Resposta

**Keywords in english**

Inductive Logic Programming  Probabilistic Logic Programming  Answer Set Programming

### Main scientific area

**Scientific domain**

Exact Sciences

**Scientific area**

Computer and Information Sciences

**Scientific subarea**

Computer Sciences

**Evaluation panel**

Computer and Information Sciences and Informatics

### Timetable

**Start date**

01.09.2024

**Duration (months)**

18

## Institutions

### Principal contractor

**Institution**

Universidade de Évora

**Research Unit**

→ NOVA Laboratory for Computer Science and Informatics
→ Cátedra High Performance Computing

**Institution description and its competencies for the development of the project**

The University of Évora is a public University organized in 5 Schools: Arts, Sciences and Technology, Social Sciences, Health and human development, Nursing and the Institute for Advanced Studies and Research. Research and Development covers several areas through 18 Research Units, all of them submitted to international evaluation.

The University of Évora has established 10 Chairs in Aerospace, Agriculture, Biodiversity, Heritage, Health, High Performance Computer, Iberian studies, UNESCO and Renewable Energies, participates in the National Roadmap of Strategic Research Infrastructures and has several research infrastructures in biodiversity, computer sciences, aerospace engineering, solar energy and heritage.

The University fosters a close link with the community, enhanced through the creation of networks, the participation in the Science and Technology Park and by establishing protocols and co-promotion research projects. The main R&D areas are: Applied Mathematics; Chemistry; Culture; Education and Psychology; Healthcare; Geophysics; History; Environment and Sea; Linguistics and Literature; Materials and Surface Science; Social and Political Sciences and Science.

The 300 running R&D projects are developed through national and international partnerships, under Horizon Europe, PRIMA, ERASMUS +, LIFE, Creative Europe, Digital Europe Programme, Cost Actions, EIT Health, EIT Urban Mobility, EEA Grants, INTERREG, PT2020, Alentejo2020, COMPETE2020, PRR, FCT or private funding.

## Collaborative institutions

| Country | Institution |
|---|---|
| PORTUGAL | Cátedra High Performance Computing |

**Institution description and its competencies for the development of the project**

The High Performance Computing Chair is a Research & Development infrastructure focused on high performance computing (HPC) and artificial intelligence (AI) research, development and deployment for scientific and industrial applications.The Chair is based at the University of Évora, endorsed by Hewlett Packard Enterprise, is a partnership of national and international higher education institutions (6), research centres (3), enterprises (13) and public/private organizations (2).

The Chair's research team is composed of 27 researchers on different career paths, with an impressive track record that includes publications in top journals in their fields, including in Nature (Atomic Physics and Astrophysics). The current research is carried out along several fundamental lines of R&D, e.g., parallel computing, artificial intelligence, computational atomic physics, computational astrophysics, computational chemistry, biochemistry, and biophysics, computational material sciences, digital humanities (heritage, literature, arts) and digital social sciences (tourism).

More details on the HPC Chair can be found in <https://catedrahpc.uevora.pt>.

# Research team

## Principal investigator

**Francisco Manuel Gonçalves Coelho** Core PI

**Ciência ID**
AF10-03F3-E074

**Institution to which you are associated in the scope of the research project**
Universidade de Évora

**CV**
Obtained in 25-02-2024 at 15:48:59 GMT

# PI Narrative CV

### Carreer profile

1. 1993, Degree in Mathematics, Faculdade de Ciências, Universidade de Lisboa.
2. 1997, MSc in Mathematics (Algebra), Faculdade de Ciências, Universidade de Lisboa. On Hilbert's tenth problem and a computational model based on geometric constructions with ruler and compass.
3. 1997, Teaching Assistant, Mathematics Department, Universidade de Évora.
4. 2006, PhD in Informatics (Computer Science), Universidade de Lisboa. On deliberation by autonomous agents.
5. 2006, Assistant Professor, Mathematics Department, Universidade de Évora.
6. 2006, Assistant Professor, Computer Science Department, Universidade de Évora.
7. 2008 -- 2021, Teaching and research and teaching activity on ideas about computing and geometry, started in the master's dissertation; the integration of logic and statistical AI; learning polynomial models using genetic algorithms, with several publications, e.g., articles and books;
8. 2021 -- present,
    - Researcher at the chair "High Performance Computing" at Universidade de Évora;
    - Integrated member of the NOVALINCS center;
    - Preparation and lecturing of courses on the Julia language, aimed at the digital humanities and social sciences, under the HPC Chair and the european projects EuroCC and EuroCC2, funded by the European Commission - EuroHPC Joint Undertaking;
    - PI of the project CPCA/A0/427668/2021, FCT, Portugal, a small FCT founded project exploring the use of "high-level" languages (Julia, Python) in distributed computing and HPC systems;
    - Work on the extension of ASP with probabilistic annotations, and respective induction by a set of data and background knowledge;
    - Supervisor of a BII scholarship

## Contributions to Science and Society

### Contributions to the generation of new ideas, tools, methodologies or knowledge

1. 2021, Mentor of i-Days: Student competition to tackle health challenges, organized by EIT-Health and StartUB!C (Universidad de Barcelona), that took place in PACT, Évora. i-Days promote health innovation among university students through dozens of one-day and two-day programmes held in academic institutions around Europe.
2. 2021, Co-author of "Lattice-Maker", a set of tools to present lattices of combinatorial games in LaTeX, used on the PhD thesis "Lattices related to Conway's construction", where I was member of the juri, and two papers where I'm co-author: DOI:10.1016/j.tcs.2014.01.025 and DOI:10.1007/s00182-020-00715-3.
3. 2017, Co-author of "Genetic Algorithms for Polynomial Regression", R code to find the best polynomial regression using genetic algorithms, used in the journal paper DOI:10.1016/j.asoc.2017.05.047.
4. 2015, Author of "Galaxity", a Java system to assess the correction of perceptions of AgentSpeak(L) agents using probabilistic methods, and used in the conference paper DOI:10.1007/978-3-319-25524-8_44.
5. 2014, Author of "TeseUE", a LaTeX class to MSc dissertations and PhD thesis in Universidade de Évora, is currently used by many students.

### Contributions to the development of individuals and/or research teams

1. 2024, Mentor of the mini-project "Automatic Differentiation", aimed at MSc and PhD students, at the Birla Institute of Technology and Science, Pilani, India, within the Asian and European Schools in Mathematics. Travel was supported by a CIMPA scholarship.
2. 2024, Lecturer of the course "An Introduction to Julia for Scholars", aimed at MSc and PhD students and researchers, at the Birla Institute of Technology and Science, Pilani, India, within the Asian and European Schools in Mathematics. Travel was supported by a CIMPA scholarship.
3. 2023, 2024, Coordinator and lecturer of the online course "Programming in Julia for Digital Humanities", aimed to digital humanities and social sciences researchers, part of the training and dissemination activities of the HPC Centre and the HPC

humanities and social sciences researchers, part of the training and dissemination activities of the HPC centre and the HPC Chair.

4. 2023, 2024, Mentor of one BII Scholarship within the scope of the multi-annual financing of the R&D unit with reference UIDP/04516/2020, financed by national funds through the FCT/MCTES.
5. 2022 -- present, Supervisor of three ongoing PhD thesis on computer science.
6. 2016 -- present, Course director and lecturer of "Introdução ao LaTeX" (Introduction to LaTeX), directed at students and researchers, at Universidade de Évora.
7. 2016, Co-author of the book "Introdução à Matemática - Álgebra, Análise e Otimização"(LIDEL), ISBN:978-989-752-209-3, addressing core mathematical subjects (algebra, calculus and optimization) for social sciences university courses. Used in the course "Matemática Aplicada à Economia e Gestão", Universidade de Évora.
8. 2010 -- present, Supervisor of six completed and three ongoing MSc dissertations about topics such as e-learning, virtual reality, serious games or game design.
9. 2010 -- present, Member of the juri in 13 academic examinations, including three as examiner.
10. 2010, co-author of the book "Teoria da Computação, Computabilidade e Complexidade", ISBN:978-972-592-281-1, where computation is explained starting with simple machines, addressing the computation limits such as the Halting Problem, polynomial equivalence and complexity. A draft version of this book was used in the course "Teoria da Computabilidade e Complexidade", Universidade de Évora.
11. 2006 -- present, Assistant professor at Universidade de Évora. Within this role I coordinated more than 26 courses, including mathematics and computer science, for graduation or MSc grades.

### Contributions to the research community and the broader society

1. 2024, An introduction course to the Julia language, for students on technical courses and researchers.
2. 2024, A mini-project/introduction course to automatic derivation with Python, for students of technical courses.
3. 2023, 2024, An introduction course to the Julia language, for researchers in the areas of digital humanities and social sciences.
4. 2024, 2023, 2010, Visited higher education institutions in India, the Czech Republic and Timor-Lorosa'e to disseminate knowledge and to establish or reinforce cooperation between Universidade de Évora and local HEI.
5. 2023, Invited Talk, "Fronteiras da Inteligência Artificial", Festival da Ciência'23, Universidade de Évora, aimed at societal engagement with science.
6. 2022 -- present, Reviewer for the "Applied Soft Computing" journal (Q1).
7. 2021 -- present, Participation in the "High Performance Computing Chair" of Universidade de Évora, as member of the scientific team, technical-scientific board, coordinator of the "Programming in Digital Humanities" task and member of five work packages.
8. 2016 -- present, Course director and lecturer of "Introdução ao LaTeX" (Introduction to LaTeX), directed at students and researchers, at Universidade de Évora.
9. 2016, 2010, Co-author of two pedagogical books, about Mathematics and Computer Science, aimed at higher education students, contributions to the dissemination of knowledge.
10. 2011 -- present, Member of several organizing and scientific committees of international scientific events. In the most recent, the international conference "Programming and Data Infrastructure in Digital Humanities", I was member of both the scientific and organizing committee.
11. 1997 -- present, Fifteen communications at scientific dissemination events, either at international conferences or invited to scientific lectures.

### Selected outputs and/or activities

**Activity "Combinatorial Games Theory" and results**

- Contributed to the development of "Lattice-Maker", a set of tools to present lattices of combinatorial games in LaTeX, available in the public repository <https://github.com/fmgc/Lattice-Maker>.
- Lattice-Maker was used by Cátia Dias on her PhD thesis "Lattices related to Conway's construction" where I was member of the juri, and in two international, indexed, jornal papers:
  - 2021, Carvalho, Dias, Coelho, Neto, Nowakowski, Vinagre, "On lattices from combinatorial game theory: infinite case", DOI:10.1007/s00182-020-00715-3
  - 2014, Carvalho, Santos, Dias, Coelho, Neto, Nowakowski, Vinagre, "On lattices from combinatorial game theory. Modularity and a representation theorem: Finite case", DOI:10.1016/j.tcs.2014.01.025

**Activity "Polynomial Regression" and results**

- Contributed to "Genetic Algorithms for Polynomial Regression", R code to find the best polynomial regression using genetic algorithms, available in the public repository <https://github.com/jpneto/GenAlgPoly>.
- This program was used in the international, indexed, journal paper
  - 2017, Coelho e Neto, "A method for regularization of evolutionary polynomial regression", DOI:10.1016/j.asoc.2017.05.047
- This is my most cited work, some of which two in 2023, six years after publishing.

**Activity "Perception Correction" and results**

- Implemented "Galaxity", a Java system to assess the correction of perceptions of AgentSpeak(L) agents using probabilistic methods, and "jpgm", a small Java library to support simple probabilistic graphical models (pgm) computations used in Galaxity. These are available in the public repositories <https://bitbucket.org/mangon/galaxity> and <https://github.com/fmgc/jpgm>.
- "Galaxity" (and "jpgm") where used in the conference paper
  - 2015, Coelho e Nogueira, "Probabilistic perception revision in AgentSpeak(L)", DOI:10.1007/978-3-319-25524-8_44

**Activity "Stochastic Answer Set Programs" and results**

- Started in 2023 and is currently my main research activity, a continuation of "Perception Correction" towards the combination of statistical ans logic AI. At this moment the outcomes of this activity are
  - BII scholarship, supported by "Financiamento Plurianual da unidade de I&D UIDP/04516/2020", co-supported by FCT, Portugal.
  - Draft programs, available in a public repository.
  - A paper, "An Algebraic Approach to Stochastic ASP", in co-authorship, recently submitted to a international conference.

### Why would this grant be timely for me at this point in my career path and/or in my research?

Given my background and this project research area there are several aspects to consider regarding the timeliness and potential impact of this project on my future research lines and development:

**Alignment with Current Expertise.** My expertise in logic and statistical AI, as evidenced by contributions to papers covering these subjects, aligns well with the objectives of the proposed project, which aims to overcome constraints in logical representations with probabilistic elements. My previous work in these areas provides a solid foundation for tackling the challenges outlined in the project.

**Interdisciplinary Collaboration.** The project emphasizes interdisciplinary collaboration, crucial in addressing complex research problems. My involvement in this interdisciplinary effort showcases my ability to collaborate across domains, enhancing my network and potentially leading to future collaborations and research opportunities.

**Contribution to the Field.** The proposed research addresses critical limitations in probabilistic logic programming, an area of increasing importance in AI and machine learning. By expanding Answer Set Programming with Stochastic Answer Set Programs, this project seeks to advance the field through innovative methodologies, such as assigning probability to general events and integration of evolutionary algorithms for model induction. My involvement can improve my profile within the academic community and position me as a competent expert in this specialized area.

**Career Development Potential.** Engaging in this project not only enhances my research credentials but also provides opportunities for career development. As a researcher, my involvement in cutting-edge research projects can strengthen my position within the academic community, attract funding for future research endeavors, and potentially lead to leadership roles within research teams or initiatives.

**Establishment of Collaborations.** This project emphasis on interdisciplinary collaboration and the integration of diverse perspectives ensures that I will have the opportunity to establish national and potential international collaborations/networks. These can lead to joint publications, participation in conferences, and access to resources that further enrich my research career.

**Potential for Future Funding.** Successful completion of the project and the generation of impactful results can significantly enhance my ability to attract funding for future research projects. My involvement in this research can strengthen my competitiveness in securing research grants.

This project aligns well with my expertise and offers significant potential for advancing my career and research development. Through interdisciplinary collaboration, contributions to the field, and the establishment of collaborations, I can leverage this project to make substantial strides in my research trajectory and position myself as a competent authority in the field of probabilistic logic programming.

## Members

## Members

**Bruno Miguel Antunes Dinis** Core Member

**Association**
Accepted

**Ciência ID**
3E1F-A94E-D147

**Institution to which you are associated in the scope of the research project**
Universidade de Évora

**CV**
Obtained in 23-02-2024 at 15:10:13 GMT

**Miguel Ângelo Pignatelli de Avillez Nunes Pereira** Core Member

**Association**
Accepted

**Ciência ID**
4110-30FC-E46E

**Institution to which you are associated in the scope of the research project**
Cátedra High Performance Computing

**CV**
Obtained in 01-03-2024 at 11:25:54 GMT

**SALVADOR LUÍS DE BETHENCOURT PINTO DE ABREU** Core Member

**Association**
Accepted

**Ciência ID**
C617-7ED4-8326

**Institution to which you are associated in the scope of the research project**
Universidade de Évora

**CV**
Obtained in 28-02-2024 at 14:19:53 GMT

## Hirings

**(BIPD - 01) Post doctoral Research Grant**

**Institution**
Universidade de Évora

**Tasks**
Integration of SASP with existing ASP and ILP software frameworks (INT) · 12 person * month

## Consultants

## Research team CV synopsis

- **Francisco Coelho** completed his PhD in Informatics in 2006 at Universidade de Lisboa under the supervision of Helder Coelho on Artificial Intelligence. Is previous formation is on Mathematics, where he has a Master degree in Mathematics, specialty Algebra, with a dissertation about Hilbert's tenth problem and about geometric computation, advised by Prof. Augusto Franco de Oliveira and Prof. José Félix Costa.

  Currently he is Assistant Professor at the Computer Science department of Universidade de Évora, where he has coordinated more than twenty courses and restructured or proposed other six, to the graduation and master degrees. He is supervising three PhD thesis and two MSc dissertations and has supervised other six completed MSc dissertations.

  He contributed with software and writing to papers covering a wide range of subjects but mostly about logic and statistical AI. He is integrated member of the Intelligent Systems of the research unit NOVALINCS and member of the scientific team of the High Performance Computing Chair.

- **Bruno Dinis** completed his PhD in Maths in 2013 at the University of Évora under the supervision of Imme van den Berg on Nonstandard Analysis.

  After his doctoral studies, he was a postdoc at the Faculdade de Ciências under the supervision of Fernando Ferreira, working on Proof Theory.

  Bruno Dinis is currently an Assistant Professor at the Universidade de Évora. Co-supervised 1 master's dissertation.

  He has written over 20 papers on several aspects of logic, for the most part in proof interpretations and its applications (proof mining).

- **Salvador Abreu** is Full Professor at the University of Évora (UE) School of Science and Technology since 2013, Senior Researcher at NOVA LINCS and President of the Scientific Council at the UE Institute for Research and Advanced Training (IIFA). He currently directs the PhD Program in Informatics at UE.

  He holds a Habilitation in Informatics from the University of Évora (2009), a PhD in Informatics from Universidade NOVA de Lisboa (1994), and a BSc in Informatics Engineering from Universidade Nova de Lisboa (1987).

  Salvador successfully supervised 9 doctoral theses and is currently directing 3. He was granted an IBM SUR award in 2013 and a JSPS Invitation Fellowship in 2015. He participates or participated as a project member or Principal Investigator in nationally and European funded projects, including OAR, AJACS, STAMPA, JEDI, HORUS, VAPS, BIOECOSYS, AI4EU, EUGREEN and PaCoMoCo.

- **Miguel Avillez** (PhD in Astrophysics) is a tenured research full professor in Astrophysics at the Institute for Research and Advanced Training, University of Évora, being the Chair-holder of the High Performance Computing Chair. He is a guest professor at the Department of Astronomy and Astrophysics of the Technical University Berlin, Germany. He is the director of the High Performance Computing Centre of the University of Évora that houses the the OBLIVION Supercomputer.

  His research focuses on theoretical and computational astrophysics, computational atomic physics, and numerical analysis, studying the evolution of the interstellar medium in galaxies, the stars life cycle, the circulation of matter between the disks and galactic halos, and, more recently, the distribution of elements in the first galaxies formed after the Big Bang. In addition he is deeply involved in software development, refactoring and acceleration to take advantage of supercomputing facilities and exascale computing. His research has been funded by, e.g., the National Science Foundation (US), American Museum of Natural History (US), Compaq (US), Portuguese Science Foundation, European Commission, European Science Foundation, DFG, European Space Agency, and NASA. Publishes regularly in top journals in the field and has published in the Nature journal.

  He has been involved in scientific working groups of major international projects, some related to the construction of space telescopes (e.g., WSO-UV, Athena, SIRIUS), and led/leads international consortia in, e.g., computational astrophysics, supercomputing in astrophysical fluid flow, and on HPC & HPDA (2019-2023) and HPC, HPDA & AI (2021-2027). He participated in the PRACE (Partnership for Advanced Computing in Europe; 2011-2021), EuroCC (National Competence Centres in the framework of EuroHPC; 2020-2022). Currently leads the WP6 (High Performance Computing) of the research infrastructure ENGAGE SKA, the Task 19.2 "Training and Awareness" of the NCC Portugal in EuroCC2 (EuroHPC JU) and the WP3 "Training" in the ATTRACT European Digital Innovation Hub, as well, as the ERASMUS+ Advanced Computing Consortium that involves 14 higher education institutions in Portugal. He was the european Benchmark Code Owner of the GADGET software (versions 2 through 4) under PRACE (2017-2021) and is European Training Champion for the projects EuroCC and EuroCC2.

# Work plan

## Abstract


### Abstract in portuguese

Esta pesquisa visa superar as restrições das representações lógicas em cenários do mundo real com elementos probabilísticos, expandindo a Programação Lógica Probabilística (PLP) com Programas Estocásticos de Conjunto de Respostas (SASP).

Embora os sistemas PLP atuais, como o ProbLog, forneçam algumas soluções, persistem desafios na caracterização de distribuições de probabilidade para Programas de Conjunto de Respostas (ASP) com factos probabilísticos. A abordagem SASP proposta introduz um método algébrico para representar a incerteza e proporciona algoritmos evolutivos para induzir modelos SASP.

O plano de pesquisa envolve análise teórica, desenvolvimento de algoritmos, avaliação empírica e colaboração interdisciplinar.

Os principais objetivos incluem investigar a estrutura e composição dos programas na modelação SASP, desenvolver regras e algoritmos de transformação e avaliar modelos SASP codificados manualmente ou induzidos em casos teóricos e do mundo real.

**Estado da arte**

- Sistemas PLP como o ProbLog permitem representações lógicas de distribuições de probabilidade
- No entanto, caracterizar distribuições de probabilidade para ASP estendidos com fatos probabilísticos permanece um desafio.
- A abordagem SASP proposta estende ASP, representa a incerteza algebricamente e incorpora algoritmos evolutivos para indução de modelos.

**Objetivos principais**

- Investigar o papel da estrutura dos programa na utilização de SASP na modelação de fenómenos probabilísticos.
- Investigar a aplicação de algoritmos evolutivos para indução de modelos SASP dado conhecimento anterior e evidências adicionais.
- Avaliar modelos SASP codificados manualmente ou induzidos, em casos teóricos e do mundo real.

**Conhecimento e competências**

- O grupo tem experiência em lógica, programação lógica e sistemas distribuídos.
- Trabalhos anteriores demonstram a viabilidade e a capacidade representativa dos SASP.
- A colaboração com uma equipe interdisciplinar garante perspetivas diversas.

**Estratégia e Metodologias**

- A análise teórica explorará os efeitos da estrutura dos programas SASP na modelação de fenómenos probabilísticos.
- O desenvolvimento de algoritmos será focado on uso de SASP para a modelação de fenómenos probabilísticos e indução de modelos SASP.
- A avaliação empírica irá apurar o desempenho dos modelos em vários casos.
- A colaboração interdisciplinar promove a inovação e garante pesquisas abrangentes.

**Novidade e resultados esperados**

- A novidade está na semântica probabilística do SASP, na pontuação do modelo SASP resultante baseada em evidência e na utilização dessa pontuação para induzir SASP a partir de conhecimento anterior e evidência.
- Os resultados esperados incluem melhor compreensão da modelação SASP, algoritmos eficientes e modelos SASP validados.

A pesquisa proposta aborda limitações críticas na programação lógica probabilística com ASP e visa avançar através de metodologias inovadoras e colaboração interdisciplinar. O plano de investigação abrangente, apoiado pelos conhecimentos e recursos existentes, demonstra um forte potencial para contribuições significativas para esse problema.

### Abstract in english

This research aims to overcome the constraints of logical representations in real-world scenarios with probabilistic elements by expanding Probabilistic Logic Programming (PLP) with Stochastic Answer Set Programs (SASP).

While current PLP systems like ProbLog provide some solutions, challenges persist in characterizing probability distributions for Answer Set Programs (ASP) with probabilistic facts. The proposed SASP approach introduces an algebraic method to represent uncertainty and integrates evolutionary algorithms for inducing SASP models.

The research plan involves theoretical analysis, algorithm development, empirical evaluation, and interdisciplinary collaboration.

Key objectives include investigating program structure and composition in SASP modeling, developing transformation rules and algorithms, and evaluating hand-coded and induced SASP models on theoretical and real-world cases.

**State of the Art**

- PLP systems like ProbLog address limitations of logical representations with probability distributions.
- However, characterizing probability distributions for Answer Set Programs extended with probabilistic facts remains challenging.
- The proposed SASP approach extends ASP, represents uncertainty algebraically, and incorporates evolutionary algorithms for model induction.

**Main Goals**

- Investigate the role of program structure in the utilization of PASP for modeling probabilistic phenomena.
- Investigate the application of evolutionary algorithms for induction of SASP models based on additional background knowledge and evidence.
- Evaluate hand-coded or induced SASP models, on theoretical and real-world cases.

**Knowledge and Skills**

- The group possesses expertise in logic, logic programming, and distributed systems.
- Previous work demonstrates the feasibility and representational power of SASP.
- Collaboration with an interdisciplinary team ensures diverse perspectives.

**Strategy and Methodologies**

- Theoretical analysis will explore SASP program structure effects on modeling probabilistic phenomena.
- Algorithm development will focus on transformation rules and efficient exploration of SASP space.
- Empirical evaluation will assess model performance on various cases.
- Interdisciplinary collaboration fosters innovation and ensures comprehensive research.

**Novelty and Expected Results**

- The novelty lies in the probabilistic semantics of SASP, the resulting score based in evidence and the utilization of that score to induce SASP from background knowledge and evidence.
- Expected results include improved understanding of SASP modeling, efficient algorithms, and validated SASP models.

Overall, the proposed research addresses critical limitations in probabilistic logic programming with ASP and aims to advance the field through innovative methodologies and interdisciplinary collaboration. The comprehensive research plan, supported by existing expertise and resources, demonstrates a strong potential for significant contributions to the field.

# Abstract for publication

### Abstract for publication in portuguese

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### Abstract for publication in english

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# State of the art and objectives

A major limitation of logical representations in real world applications is the implicit assumption that the background knowledge (BK) is perfect. This assumption is problematic when dealing with probabilistic phenomena, which is often the case. Probabilistic Logic Programming (PLP) is one ongoing effort to address this problem by extending the syntax and semantics of logic programs in order to have them represent and operate probability distributions (see [11]).

Answer Set Programming (ASP) [12] is a logic programming paradigm based on the stable model semantics of normal programs that can be implemented using the latest advances in SAT solving technology. Unlike ProLog, ASP is a truly declarative language that supports language constructs such as disjunction in the head of a clause, choice rules, and both hard and weak constraints.

Current systems for PLP, such as ProbLog [5], P-log [3], LP^MLN [6], or cplint [7], derive a unique probability distribution from the probabilistic facts of a Prolog-like program. However, if instead of Prolog we consider ASP with probabilistic facts, the characterization of a probability distribution on the program's domain is no more uniquely determined (see [1, 2, 3, 4]).

In our recent, yet unpublished, work [8] we address the problem of extending probability from the probabilistic facts of an (extended) ASP program to its stable models and, from there, to general events. Our approach is algebraic in the sense that it relies on an equivalence relation over the set of events and non-uniqueness is expressed by algebraic variables related by polynomial expressions. In that work we show how SASP can represent arbitrary bayesian networks and therefore express any probability distribution of discrete random variables.

This representation of arbitrary bayesian networks conferes to SASP the capability to deal with a very large collection of probability problems and tasks. However, the problem of obtaining such SASP, besides hand-coded, remains open.

In our system some unknowns are represented by algebraic variables that can be estimated later from further information, e.g., evidence. This approach, delaying the assignment of these variables, enables later refinement and assigning a score to a partial program from additional evidence, measuring the error between the program's probability distribution and the empirical distribution from the evidence.

In turn, scoring of SASP (i.e., models of probabilistic phenomena) is a feature that can be utilized with the application of evolutionary algorithms. From here we can explore how to induce SASP from BK and evidence, using the SASP score as a fitness function for the selection step in evolutionary algorithms.

The calculus of the score of an SASP with respect to evidence was already introduced and illustrated in [8]. It remains to investigate the application of this process to induction of SASP from BK and evidence.

Ideas of this paper have a partial, limited, implementation, available in a public repository, that results from the work of a BII scholarship, supported by NOVALINCS "Financiamento Plurianual da unidade de I&D UIDP/04516/2020" and co-supported by Fundação para a Ciência e a Tecnologia (FCT), Portugal.

In the general Induction of Logic Programs (ILP) setting (see [11, 13]), the goal is to algorithmically obtain a (target) logic program consistent with BK and evidence. For that, (1) BK (e.g., obtained from experts) is provided in the form of a logic program, that describes objects and (first-order) relations of a domain and (2) observations are organized as positive evidence, that should be inferred from the target program, and negative evidence, that should not be inferred from the target program. Moreover, the target program must be (logically) consistent with the BK. ILP is a form of Machine Learning (ML) that offers significant advantages over numeric based ML.

For one, ILP address the problem of Explainable Artificial Intelligence (XAI) because, unlike the large-dimensional vector based models of numeric ML, logic programs are human-readable in the sense that their declarative nature describes what objects are in the domain, their structure, properties and relations.

Second, ILP describes phenomena with related instances while numeric ML is limited to a single (tabulated) relation where different instances (lines) are independent given the model.

Third, often a target program is generated from a small set of observations, while, in general, numeric ML models require large datasets to achieve significant accuracy.

At last, expert knowledge, expressed in the BK, can be utilized to structure the target program, i.e., to model the observations. Again, this is a feature hard to achieve with numeric ML models.

Drawbacks of ILP include the computational complexity of inducing the target program and the general difficulty of logic programs to deal with data from probabilistic phenomena. While the later is being addressed by PLP in general and SASP in particular, the computational complexity of induction remains an important challenge that we propose to address with this project objectives.

We aim to continue our exploration, started in the work described in [8] and a BII scholarship, on how SASP represent probability distributions, how to use them to model probabilistic phenomena and how they can be induced from BK and evidence.

More specifically, this project's objectives are to investigate:

- The role of program structure and composition in the use of PASP to model probabilistic phenomena.
- Program transformation rules and space exploration algorithms for SASP.
- The performance of hand-coded and induced SASP models on selected theoretic and real world cases.

# Research plan and methods

**Feasibility and Originality**

The outlined scientific approach leverages existing developments in Probabilistic Logic Programming (PLP) and Answer Set Programming (ASP) and extends it with the concept of Stochastic Answer Set Programs (SASP) to represent probability distributions in scenarios where traditional logical representations fall short due to probabilistic phenomena. The novelty lies in the application of algebraic methods to express uncertainty and the integration of evolutionary algorithms for inducing SASP models. Feasibility is supported by previous work demonstrating the representational power of SASP. Originality is derived from the interpretation of PLP and ASP concepts with an original approach to the association of probability annotated facts in logic programs to the probability of events, and the proposed investigation into program induction from background knowledge and

evidence.

**Research Methodology**

1. **Theoretical Analysis.** Conduct a thorough analysis of the role of program structure and composition in the utilization of PASP for modeling probabilistic phenomena. This involves investigating how different program structures impact the representation and inference capabilities of SASP.
2. **Algorithm Development.** Develop program transformation rules and space exploration algorithms tailored for SASP. This includes devising methods to efficiently transform SASP representations and explore the space of possible SASP models.
3. **Empirical Evaluation.** Evaluate the performance of both hand-coded and induced SASP models on a range of theoretic and real-world cases. This involves designing experiments to assess the accuracy, scalability, and computational efficiency of SASP models in comparison to existing PLP systems.
4. **Integration of Evolutionary Algorithms.** Investigate the application of evolutionary algorithms for refining SASP models based on additional background knowledge or evidence. Develop algorithms to update SASP parameters and structure to improve model fit to observed data.

**Working Arrangements**

- Collaborative Environment. Foster collaboration between researchers with expertise in logic, logic programming, and distributed systems to ensure interdisciplinary perspectives are considered.
- Regular Meetings. Schedule regular meetings (e.g., every three/four months) to discuss progress, address challenges, and align research efforts towards the project objectives.
- Access to Resources. Ensure human and computational resources for theoretical research, algorithm development, experimentation, and data analysis.

**Timeline**

1. **Task Structure and Induction of SASP (SI) (Months 1-12)**
   - Theoretical research on program structure and transformation rules conducted by an interdisciplinary team of three members, including the PI.
   - Identifications of relevant program structure and transformation rules.
   - Regular meetings and discussions to ensure progress and collaboration within the team.
   - Publication of research findings in peer-reviewed international journals or presentations at international conferences.
2. **Task Integration with existing ASP and ILP software frameworks (INT) (Months 3-15)**
   - Implementation, testing, profiling, benchmark, and documentation conducted by a post-doctoral researcher.
   - Translation of theoretical findings into practical algorithms and software tools.
   - Rigorous testing of implemented solutions to ensure correctness and efficiency.
   - Profiling to identify computation intensive points for improvement.
   - Benchmark against existing methods to evaluate performance and identify areas for improvement.
   - Comprehensive documentation of the developed methodologies, including user guides and technical reports.
   - Continuous refinement based on feedback from internal testing and validation.
   - Publication of research findings in peer-reviewed international journals or presentations at international conferences.
   - Dissemination of outcomes through seminars, and open-source repositories.
3. **Task Applications of SASP (APP) (Months 6-18)**
   - Application of developed methodologies and software tools to theoretical and real-world problems.
   - Case studies and experiments conducted to assess the effectiveness and scalability of the proposed approaches.
   - Analysis of results and comparison with existing state-of-the-art methods.
   - Publication of research findings in peer-reviewed international journals or presentations at international conferences.
   - Dissemination of outcomes through seminars, and open-source repositories.

**Resources**

- **Personnel**
  - PI: Leads and coordinates all tasks, providing guidance and oversight throughout the project duration.
  - Interdisciplinary team (4 members, including the PI): Comprising experts in logic, logic programming, and distributed systems, responsible for theoretical research, development and case exploration.
  - Post-doctoral researcher: Leads the implementation, testing, profiling, benchmark, and documentation efforts.
- **Equipment and Infrastructure**
  - High-performance computing resources for conducting complex simulations and experiments.
  - Software and hardware development tools and platforms for coding, testing, and version control.
  - Access to relevant databases, datasets, and computational libraries for validation and benchmark.
- **Funding**
  - Budget allocation for equipment procurement, travel expenses, publication fees, and other project-related costs.
  - Grant funding to sustain the research and software tools development activities over the designated timeline.

**PI Commitment**

As the Principal Investigator (PI), I am fully committed to overseeing and ensuring the success of each phase of the research project. My responsibilities include:

- Providing strategic direction and vision for the research activities.
- Facilitating interdisciplinary collaboration among team members.
- Securing necessary resources and funding to support the project goals.
- Monitoring progress and addressing any challenges or setbacks that may arise.
- Ensuring compliance with ethical guidelines and research protocols.
- Contributing to the dissemination of research outcomes through publications, presentations, and knowledge sharing initiatives.
- Mentoring and supporting team members to foster their professional development and growth.

Throughout the project duration, I will maintain open communication channels with all stakeholders, including team members, funding agencies, and collaborators, to ensure transparency and alignment with project objectives. My dedication to the project's success is unwavering, and I am committed to achieving impactful results that advance the field of probabilistic logic programming and inductive logic programming.

**Justification**

The proposed research methodology aligns with the project's objectives by combining theoretical analysis, algorithm development, empirical evaluation, and interdisciplinary collaboration. The utilization of existing PLP frameworks as a foundation and the integration of evolutionary algorithms introduce innovative elements to address the challenges of data with random perturbations and computational complexity in logic-based probabilistic reasoning. The allocated timelines, resources, and PI's commitment are justified by the ambitious nature of the research objectives and the potential impact of the proposed advancements in probabilistic logic programming.

**Identify whether the work plan requires advanced computer resources to be provided by FCT**

Yes

**Identify whether the work plan requires space in a research data repository to be provided by the FCT**

Yes

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Dinis, B., & Miquey, É. (2023). Stateful Realizers for Nonstandard Analysis. Logical Methods in Computer Science, 19.
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## Tasks

SUMMARY OF COSTS BY INSTITUTION

| **Universidade de Évora** | |
|---|---|
| 1. Structure and Induction of SASP (SI) | 4 440,00 € |
| 2. Integration of SASP with existing ASP and ILP software frameworks (INT) | 34 735,00 € |
| 3. Applications of SASP (APP) | 2 220,00 € |
| **Total** | **41 395,00 €** |

1 **Structure and Induction of SASP (SI)** 12 months From 01.09.2024 to 31.08.2025

**Members**

| **Persons / Month** | **Allocated** |
|---|---|
| 2 | Bruno Miguel Antunes Dinis<br>Universidade de Évora |
| 2 | Francisco Manuel Gonçalves Coelho<br>Universidade de Évora |
| 1 | SALVADOR LUÍS DE BETHENCOURT PINTO DE ABREU<br>Universidade de Évora |

**Task description and expected results**

**Objectives**

Understand the role of Stochastic Answer Set Programs (SASP) structure and composition elements (e.g., stratified or recursive programs, functional symbols) on the stable models, event classes, respective probability and SASP scoring with

recursive programs, functional symbols) on the stable models, event classes, respective probability and SASP scoring with respect to evidence (i.e., a dataset).

Understand what are the best choices for program transformation and combination rules for induction of SASP from Background Knowledge (BK) and evidence using evolutionary program space exploration algorithms (e.g., genetic algorithms).

**Methodologies and approaches**

- List structure elements (e.g., stratified programs, recursive rules, functional symbols) and explore the respective effects on the stable models and event classes.
- Modify the definition of event classes and study the effect on event probability and score function in modeling probabilistic processes
- Define SASP transformation and combination rules to study and characterize the resulting properties of evolutionary program space exploration algorithms for the induction of SASP from BK and evidence.

**Expected results**

- Assessment on the effects of SASP structures and composition elements on stable models, event classes, respective probability and SASP scoring with respect to evidence for the use of SASP in modeling probabilistic processes.
- Assessment of SASP transformation and combination rules and the resulting properties of evolutionary program space exploration algorithms for the induction of SASP from BK and evidence.

**Preconditions from other tasks**

None. This is an initial task, a continuation of previous research.

**Results to other tasks**

Expected result of this task gives important insights into tasks INT and APP:

- The use of SASP in modeling probabilistic processes, because it studies the elements utilized in the computation of the event classes and respective probabilities.
- The induction of SASP from BK and evidence, because it studies program transformation and combination rules utilized in evolutionary program space exploration algorithms.

**Role of each partner and institution**

- **Universidade de Évora**: Principal contractor.
- **Francisco Coelho**'s expertise in Informatics and AI, coupled with his extensive teaching and research experience, qualifies him to investigate SASP structures and their role in probabilistic modeling. His contributions to logic and statistical AI ensure insightful analysis of SASP transformation rules. The expected results will deepen understanding of SASP's applicability in modeling probabilistic processes.
- With expertise in proof theory and logic, **Bruno Dinis** is well-equipped to analyze SASP structures and transformation rules. His research background ensures insightful assessment of SASP's role in logic modeling, contributing to advancements in algorithmic induction methodologies.
- **Salvador Abreu**'s vast experience in informatics, leadership in research, and project management make him invaluable for analyzing SASP structures. His insights will enhance understanding of SASP's role in probabilistic modeling and optimize induction methodologies.

**Justification for the resources**

- For deliverable "SI Paper 1": A member should present the results of this task in an international, peer-review, conference or journal.
- For deliverable "SI Paper 2": A member should present the results of this task in an international, peer-review, conference or journal.

### Deliverables and delivery dates

Paper accepted in international, peer-review, conference or journal, by 2025-03-01

Paper accepted in international, peer-review, conference or journal, by 2025-09-01

### Overall cost justification of the task

Registration in international conference (SI Paper 1 + SI Paper 2).....1400.00€

Travel to international conference (SI Paper 1 + SI Paper 2).....1000.00€

Per diem international conference ((SI Paper 1 + SI Paper 2) x 3 days)....1152.00€

### Budgets

| Institution | Amount requested |
| --- | --- |

| Institution | Amount requested |
|---|---|
| Universidade de Évora | 4 440,00 € |

2 **Integration of SASP with existing ASP and ILP software frameworks (INT)** 12 months From 01.12.2024 to 30.11.2025

**Members**

| Persons / Month | Allocated |
|---|---|
| 2 | Francisco Manuel Gonçalves Coelho<br>Universidade de Évora |
| 12 | BIPD - 01 Post doctoral Research Grant<br>Universidade de Évora |

**Task description and expected results**

**Objectives**

Support the application of SASP for modeling probabilistic processes and induce SASP from Background Knowledge (BK) and evidence.

**Methodologies and approaches**

**Implement** (writing code according to the software design specifications), **test** (verify that the implemented software functions correctly and meets the requirements), **profile** (analyze the performance of the software system to identify bottlenecks, memory leaks, and other performance issues), **benchmark** (compare the performance of the software system against standard benchmarks or other systems) **and document** (provide comprehensive information about the software system, including its purpose, features, architecture, installation instructions, and usage guidelines):

- SASP intermediate representation and a parser.
- Integration with existing, state of the art, Answer Set Program (ASP) tools such as Potassco and cplint for the computation of the stable models.
- Instrumental functions such as: event belongs to class, class probability, event probability.
- Support for SASP combination and transformation.
- Integration with existing, state of the art, evolutionary explorations tools (e.g. genetic algorithms).
- Command-line programs to support basic usage such as: list classes, query the probability of an event or class, induce SASP.

**Expected results**

A basic set of tools, including a library and command-line programs, to use Stochastic Answer Set Programs (SASP) for modeling probabilistic processes and induce SASP from Background Knowledge (BK) and evidence.

**Preconditions from other tasks**

From task SI:

- Insights on the relation of SASP structure and composition elements and the computation of classes, and element and class probability.
- Insights on the effects of SASP transformation and combination rules on evolutionary program space exploration algorithms.

**Results for other tasks**

The software tools required by task APP to use and/or induce SASP on large problems.

**Role of each partner and institution**

- **Universidade de Évora**, Principal contractor.
- **Francisco Coelho**, PhD in Informatics, specializes in AI and mathematics. His experience as Assistant Professor at Universidade de Évora, and contribution to SASP, ensures a effective supervision of the work of the post-doc student.
- The **post-doc student** will implement, test, profile, benchmark, and document software for SASP integration with existing ASP tools.

**Justification for resources**

The software development volume and complexity requires a full-time post-doc student working over a year.

A suitable laptop (e.g., i7, 32GB ram, 1TB SSD, 15") is required to the support such development.

The student should present the results of this task in an international, peer-review, conference or journal.

### Deliverables and delivery dates

A report on progress, documenting the implementation, testing, benchmarking and documentation of the tools, by 2025-06-01.

Paper accepted in international conference or journal, by 2025-12-01.

### Overall cost justification of the task

Registration in international conference.....700.00€

Travel to international conference.....500.00€

Per diem international conference (x3).....576.00€

Laptop (i7, 32GB ram, 1TB SSD, 15").....2660.00€

Post-doc scholarship (BPD) (12 x (1801,00€ + 145,00€))...23352.00€ (Scholarship + SSV + Insurance per month)

### Budgets

| Institution | Amount requested |
|---|---|
| Universidade de Évora | 34 735,00 € |

## 3 Applications of SASP (APP)

12 months From 01.03.2025 to 28.02.2026

### Members

| Persons / Month | Allocated |
|---|---|
| 2 | Francisco Manuel Gonçalves Coelho<br>Universidade de Évora |
| 1 | Miguel Ângelo Pignatelli de Avillez Nunes Pereira<br>Cátedra High Performance Computing |
| 1 | SALVADOR LUÍS DE BETHENCOURT PINTO DE ABREU<br>Universidade de Évora |

### Task description and expected results

**Objectives**

Use Stochastic Answer Set Programs (SASP) for modeling probabilistic processes and induce SASP from Background Knowledge (BK) and evidence in the context of theoretic scenarios (toy problems) described in the relevant literature (e.g., Stochastic Plan Generation, Logic/Statistic Puzzles) as well as to a selected real-world cases, including modelling resource allocation in distributed, high performance computing systems.

**Methodologies and approaches**

- Compile a set of theoretic and real-world problems, including resource allocation in distributed, high performance computing systems.
- Gather information in the form of background knowledge (e.g., from experts) and data (positive and negative examples) on selected problems.
- Evaluate the performance of hand-coded and induced SASP models on that set of problems.
- Compare with state-of-the-art results.

**Expected results**

- Assessment of the performance of hard-coded and induced SASPs on selected theoretical and real-world problems, with focus on resource allocation in distributed, high performance computing systems.
- Hard-coded or induced models of the addressed cases.
- A list of advantages and problems in the application of SASP.

**Preconditions from other tasks**

From task SI:

- Insights on the relation of SASP structure and composition elements and the computation of classes, and element and class probability.
- Insights on the effects of SASP transformation and combination rules on evolutionary program space exploration algorithms.

From task INT:

- Libraries, programs, and respective documentation.

**Results for other tasks**

None. This is a final task.

**Role of each partner and institution**

- **Universidade de Évora**: Principal contractor.
- **High Performance Computing Chair**: Research unit.
- **Francisco Coelho**'s experience in informatics, mathematics, and AI makes him instrumental in SASP modeling. His supervision ensures rigorous evaluation, leading to insights into SASP's applicability and challenges.
- **Salvador Abreu**'s expertise in informatics and extensive project involvement make him pivotal for SASP modeling. His leadership will ensure thorough problem compilation, data gathering, and performance evaluation, yielding insights into SASP's effectiveness.
- **Miguel Avillez**'s profound expertise in astrophysics and high-performance computing is vital for SASP modeling of resource allocation in distributed, high performance computing systems. His leadership ensures comprehensive problem evaluation and performance assessment, yielding insights into SASP's applicability and limitations.

**Justification for the needed resources**:

A member should present the results of this task in an international, peer-review, conference or journal.

### Deliverables and delivery dates

A report on progress, documenting the performance of the hand-coded and induced PASP models on the selected problems, by 2025-09-01.

A paper accepted in an international, peer-review, conference or journal, by 2026-03-01.

### Overall cost justification of the task

Registration in international conference.....700.00€

Travel to international conference.....500.00€

Per diem international conference (x3).....720.00€

### Budgets

| Institution | Amount requested |
|---|---|
| Universidade de Évora | 2 220,00 € |

## Project timeline and management

### Milestone list

| Date | Designation | Description | Tasks |
|---|---|---|---|
| 01.03.2025 | SI Paper 1 | A paper accepted in an international, peer-review, conference or journal, describing the effects of structures and composition elements on SASP on stable models, event classes, and respective probability. | 1. Structure and Induction of SASP (SI) |
| 01.06.2025 | INT Report | A report on progress, documenting the implementation, testing, profiling, benchmark and documentation of the tools. | 2. Integration of SASP with existing ASP and ILP software frameworks (INT) |
| 01.09.2025 | SI Paper 2 | A paper accepted in an international, peer-review, conference or journal, describing | 1. Structure and Induction of SASP (SI) |

| | | | |
|---|---|---|---|
| | | program transformation rules and space exploration algorithms for SASP. | |
| 01.09.2025 | APP Report | A report on progress, documenting the performance of the hand-coded and induced PASP models on selected problems. | 3. Applications of SASP (APP) |
| 01.12.2025 | INT Paper | A paper accepted in an international, peer-review, conference or journal, describing the performance of the implemented tools on hand-coded and induced SASP. | 2. Integration of SASP with existing ASP and ILP software frameworks (INT) |
| 01.03.2026 | APP Paper | A paper accepted in an international, peer-review, conference or journal, documenting the performance of the hand-coded and induced PASP models on selected problems. | 3. Applications of SASP (APP) |

### Timeline

timeline.pdf

Obtained on 27-02-2024 at 21:55:52

### Description of the management structure

**Coordination Between Participants**

- **Principal Investigator (PI)**
  - Leads the overall project and ensures alignment with objectives.
  - Facilitates communication between participants from different research units.
  - Provides guidance and support to team members.
- **Researchers**
  - Collaborate closely with the PI to execute project tasks.
  - Coordinate with each other to ensure seamless progress on individual and collaborative activities.
  - Contribute expertise from their respective research units to enhance project outcomes.
- **Postdoctoral Student**
  - Works closely with the PI and researchers to implement project tasks.
  - Collaborates with other team members to integrate research findings into software tools and algorithms.

**Planned Meetings**

- **Quarterly Team Meetings**
  - Purpose: Discuss progress, challenges, and next steps for the quarter; Provide a comprehensive overview of progress across all project tasks.
  - Agenda: Review individual tasks, share updates, address any issues or roadblocks; Review achievements, challenges, and goals for the upcoming month.
- **Semiannual Review Meetings**
  - Purpose: Conduct a detailed review of project milestones and objectives.
  - Agenda: Evaluate progress, identify any necessary adjustments to the research plan, discuss potential collaborations or partnerships.

**Reporting Structure**

- **Progress Reports**
  - Format: Written reports submitted every three months by each team member.
  - Content: Summarize achievements, challenges, and goals for the upcoming month.
- **Semiannual Review Reports**
  - Format: Comprehensive reports submitted by the PI summarizing progress and outcomes over the past six months.
  - Content: Review achievements, challenges, adjustments to the research plan, and any recommendations for the future.

**Financial and Administrative Management**

The Administrative Services of the University of Évora are responsible for project's financial and administrative management, through its Projects Management Division (DGP).

DGP's main task is to fulfill all the necessary operations, provide administrative support and reassure the good execution of R&D Units budgets and respective Projects. It is accountable for the execution of all legal and required financial reports.

Each project is the responsibility of a project officer that acts as a link between the PI and the rest of the financial team. Is also responsible to process all expenses fulfilling all the current national and European legislation.

The project officer is also in charge of the liaison with FCT (Science and Technology National Agency), European Commission and other donors by elaborating and delivering the financial reports and respective requests for payments, including reassuring all necessary procedures to the validation of expenditures.

The University of Évora owns an information system that allows the researcher to follow the project's financial implementation on a permanent basis.

# Ethical issues

**Are there Ethics Issues identified in this project?**

No

**Ethical declarations you consider appropriate**

-

**Justification**

-

# 2030 Agenda

**Framework of the application for the United Nations SDG 2030 Agenda**

SDG Goal 9: Industry, Innovation and Infraestructures

**Framework justification**

Application of this project include the optimization in the use of existing infrastructure, therefore in accordance to **Target 9.b:** *Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.* **Indicator 9.b.1:** *Proportion of medium and high-tech industry value added in total value added.*

# Other projects

**CPCA/A0/427668/2021** Fundação para a Ciência e a Tecnologia - FCT, I.P.

**PI**

Francisco Coelho (PI)

**Project status**

Completed

**Project title (in English)**

JuPy | High Level Languages on HPC

**Principal contractor**

High Performance Computing Chair

**Total funding**

185,00 €

**Start date** **Duration (months)**

21.01.2022 3

**Main objectives of the project that you consider relevant for this application**

- Knowledge and experience acquired about implementing and executing programs in a distributed HPC system.
- Technical and scientific cooperation relationships established between the PI and the management team of the "Oblivion | HPCUE" cluster

Oblivion | HPC CoE cluster.

## Attachments

-

# Indicators

## Expected output indicators

| Description | 2024 | 2025 | 2026 | Total |
|---|---|---|---|---|
| **A · Publications** | 0 | 0 | 0 | |
| Books | 0 | 0 | 0 | **0** |
| Book chapters | 0 | 0 | 0 | **0** |
| Papers in international journals | 0 | 0 | 0 | **0** |
| Papers in national journals | 0 | 0 | 0 | **0** |
| **B · Communications** | 0 | 0 | 0 | |
| Communications in national meetings | 0 | 0 | 0 | **0** |
| Communications in international meetings | 0 | 3 | 1 | **4** |
| **C · Reports** | 0 | 2 | 0 | **2** |
| **D · Organization of seminars and conferences** | 0 | 0 | 0 | **0** |
| **E · Advanced training** | 0 | 0 | 0 | |
| PhD theses | 0 | 0 | 0 | **0** |
| Master´s theses | 0 | 0 | 0 | **0** |
| Others | 0 | 1 | 0 | **1** |
| **F · Models** | 0 | 0 | 0 | **0** |
| **G · Software** | 0 | 0 | 0 | **0** |
| **H · Pilot plants** | 0 | 0 | 0 | **0** |
| **I · Prototypes** | 0 | 1 | 1 | **2** |
| **J · Patents** | 0 | 0 | 0 | **0** |
| **K · Others** | 0 | 0 | 0 | |
| API documentation | 0 | 1 | 1 | **2** |
| Library documentation | 0 | 1 | 1 | **2** |
| | 0 | 0 | 0 | **0** |

## Release

**Promotion actions of the scientific activity planned in the project**

- Publications in international, peer-review, conferences or journals.
- Public repositories with software and documentation, datasets and models.

# Budget

## Principal contractor

### Universidade de Évora

| Item | 2024 | 2025 | 2026 | Total |
|---|---|---|---|---|
| Human Resources | 1 946,00 € | 21 406,00 € | 0,00 € | **23 352,00 €** |
| Missions | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Scientific and technical instruments and equipment | 2 660,00 € | 0,00 € | 0,00 € | **2 660,00 €** |
| Subcontracts | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Patents registration | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Demonstration, Promotion and Dissemination | 0,00 € | 5 328,00 € | 1 776,00 € | **7 104,00 €** |
| Adaptation of buildings and facilities | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Purchase of goods and services | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Overheads | 1 151,50 € | 6 683,50 € | 444,00 € | **8 279,00 €** |
| Total | **5 757,50 €** | **33 417,50 €** | **2 220,00 €** | **41 395,00 €** |

## Global budget

| Item | 2024 | 2025 | 2026 | Total |
|---|---|---|---|---|
| Human Resources | 1 946,00 € | 21 406,00 € | 0,00 € | **23 352,00 €** |
| Missions | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Scientific and technical instruments and equipment | 2 660,00 € | 0,00 € | 0,00 € | **2 660,00 €** |
| Subcontracts | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Patents registration | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Demonstration, Promotion and Dissemination | 0,00 € | 5 328,00 € | 1 776,00 € | **7 104,00 €** |
| Adaptation of buildings and facilities | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Purchase of goods and services | 0,00 € | 0,00 € | 0,00 € | **0,00 €** |
| Overheads | 1 151,50 € | 6 683,50 € | 444,00 € | **8 279,00 €** |
| Total | **5 757,50 €** | **33 417,50 €** | **2 220,00 €** | **41 395,00 €** |

## Funding plan

| Item | 2024 | 2025 | 2026 | Total |
|---|---|---|---|---|