

DECRETO RETTORALE

Decree of the Rector n. 470 of 22/05/2024

Competition for awarding 1 research grant at the University of Udine

DISCLAIMER:

The official and legally binding call for applications is in Italian only.

This document cannot be used for legal purposes and is only meant to provide information in English on the call for applications (Decree of the Rector n. 470 of 22/05/2024). Please refer to the official call published on: <https://www.uniud.it/it/albo-ufficiale>

Any change and integration will be made available on the above-mentioned web page. Therefore, no personal written communication regarding the examination date and/or competition results shall be provided to applicants.

Annex 1

Call for applications for the award of 1 grant for the performance of research activities at the University of Udine on the topic "Integration of machine learning techniques in runtime verification" SSD: INF/01 (principal investigator, Luca Geatti).

Research fellowship financed with the resources of the research project titled "Interconnected Nord-Est Innovation Ecosystem" (iNEST) - ECS_00000043. Public call No. 3277 of 30/12/2021. Young Researchers' Call – Project PNRR_M4C2_Inv.1.5_iNEST_CC5_YRC_Pj_Geatti. CUP G23C22001130006.

Art. 1

A selection proceeding is hereby announced for the award of 1 research grant at the University of Udine for the performance of the research activity identified in Annex A, which forms an integral and substantial part of this call. The research grant is linked to the research project on which it is based and is subject to the corresponding financial coverage.

Specifically, the project is placed within the context of the Italian National Recovery and Resilience Plan (i.e., PNRR) – Mission 4: Education and research, Component 2: From research to business, Investment 1.5: Creating and strengthening "innovation ecosystems", building "local R&D leaders", funded by the EU-Next GenerationEU; Project: "Interconnected Nord-Est Innovation Ecosystem" (iNEST), ECS00000043; Thematic area: Digital, Industry, Aerospace. CUP: G23C22001130006. A Young Researchers' Call has been issued within the context of the iNEST program, for the financing of research projects addressed to young researchers at universities that are part of the program as either Spoke leaders or affiliates. Among the winners of the call is Dr. Luca Geatti's project titled "Integration between runtime verification and machine learning" - Project PNRR_M4C2_Inv.1.5_iNEST_CC5_YRC_Pj_Geatti, which envisages a further call for a one year-long research grant.

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The grant may be renewed with the winner in accordance with the provisions of Article 22 of Law no. 240 of 30 December 2010 (in the text prior to Leg. Decree no. 36 of 30 April 2022, converted with amendments by Law no. 79 of 29 June 2022) and the Regulations of the University of Udine for the awarding of research grants issued by Rector's Decree no. 182 of 31 March 2021, in the presence of a positive assessment by the scientific supervisor of the activity carried out by the research fellow, adequate scientific justification and related financial coverage, within the limits set out in Article 3, letters b) and c) below.

The activities covered by the research grant will respect the National Recovery and Resilience Plan's "Do No Significant Harm" principle, i.e., they should not cause significant harm to the environment.

This call guarantees respect for generational, gender and territorial equal opportunities.

The results of the research conducted within the framework of the research grant and the related data will be published in accordance with the "Open Science" and "FAIR data" principles.

The research grant does not entitle the successful candidate to any rights as regards access to University roles.

Any personal communication to candidates relating to this selection will be sent exclusively to the email address indicated in the application form.

Art. 2

The activities covered by the research grant referred to in this call for competition and the admission requirements are indicated and described in Annex A. Failure to meet the admission requirements at the time of applying shall result in the **exclusion** of the candidate from the selection process.

Possession of a PhD qualification or equivalent qualification obtained abroad or, for the sectors concerned only, of a medical specialisation qualification accompanied by an adequate scientific production, constitutes a preferential requirement for the awarding of the grant envisaged for this selection, if it has not been mentioned as an admission requirement.

The Selection Board shall assess, for the sole purpose of admission to the competition, the suitability of any qualification obtained abroad, without prejudice to the assessment of the medical specialisation qualification to which Article 38, paragraph 3.1 of Legislative Decree 165/2001, as amended, and the relevant Community regulations apply.

The Board assesses the qualification obtained abroad based on the relevant documentation enclosed with the application to take part in the selection and may exclude the candidate if the submitted documentation does not provide sufficient elements for the assessment.

Candidates are therefore invited to enclose all documentation in their possession relating to their qualifications in order to provide the Board with sufficient elements to assess their position.

Candidates are admitted to the selection process subject to a reservation and their exclusion, for failure to meet the requirements, may be ordered at any time by reasoned decision.

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Art. 3

The research grant referred to in this call cannot be awarded to the following subjects:

- a) Employees of Universities and the entities referred to in Article 22(1) of Law no. 240 of 30 December 2010 (in the text prior to Leg. Decree no. 36 of 30 April 2022, converted with amendments by Law no. 79 of 29 June 2022).
- b) Recipients of previous research grants pursuant to Law no. 240 of 30 December 2010, for the maximum period allowed by the regulations, excluding the period in which the grant was received in conjunction with a PhD, up to the legal duration of the relevant course.
- c) Those who have already been awarded research grants and fixed-term researcher contracts pursuant to Law no. 240 of 30 December 2010 for a total of 12 years, even if not consecutive.
- d) Those who have a degree of kinship or relationship, up to and including the fourth degree, with:
 - The Rector, the Director General or a member of the Board of Directors of the University of Udine.
 - The principal investigator or a professor/researcher belonging to the department or structure of interest where the research grant activity takes place.

The research grant referred to in this call cannot be cumulated with the following:

- a) Awarded scholarships of any kind, except those granted by national or foreign institutions useful for supplementing, by means of stays abroad, the fellow's training or research activities.
- b) Other research grants.
- c) Employment relationships, even if part-time, without prejudice to the provisions of the regulations for employees of public administrations.

The grant referred to in this call is also incompatible with simultaneous attendance of degree courses, master's degrees, and PhDs with scholarships and medical specialisation, in Italy and abroad.

Persons who have been convicted of a criminal offence resulting in disqualification from holding public office or inability to contract with the public administration as a secondary penalty are not eligible for selection.

Art. 4

Applicants must submit, in the manner described in Article 5 below, the application to take part in the selection, duly signed in handwritten or digital form. An application without a signature will result in the **exclusion** of the candidate, except in the case of access through the use of the Public Digital Identity System (SPID) in which case the signature will not be necessary.

The application must be uploaded in its entirety (i.e., every page), **otherwise** the applicant will be **excluded** from the selection.

Applicants must enclose the following with their application for participation in the selection, **under penalty of exclusion**:

1. The professional scientific *curriculum vitae* in Italian or English or one of the additional languages, if any, indicated in Annex A, highlighting the candidate's aptitude for carrying out and implementing the research programme.
2. Copy of valid identity document or other identification document. Citizens of non-EU countries must enclose a copy of their passport.
3. Limited to citizens of non-EU states residing or authorised to reside in Italy, a copy of their residence permit or authorisation to reside in Italy.

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4. For candidates who cannot provide a self-certification under the conditions set out below, documentation proving possession of the academic qualification required for admission to the selection. Possession of a higher academic qualification does not exempt the candidate from producing such documentation, which, if missing, will result in exclusion:
- **Candidates who are Italian citizens or citizens of a European Union Member State** must submit a declaration in lieu of certification and, if necessary, a notarial deed regarding the academic qualification needed for admission (indicating the academic qualification, the academic institution awarding the qualification, the year it was awarded and the mark obtained) and the publications and other qualifications held, indicating for each one all the identification details necessary for the Board's assessment. **The application for participation counts as a declaration in lieu of certification of the declared academic qualification.** If the subject matter of the declaration is not clearly identified in terms of its nature, duration, time setting and institution concerned, the selection board will disregard it. The Administration reserves the right to carry out appropriate checks on the truthfulness of the content of the declarations made; in the event of a false declaration, the provisions of Article 76 of Presidential Decree no. 445/2000 and Articles 483, 485, and 486 of the Italian Criminal Code shall apply. The University will not take into account any certificates attached by candidates who are Italian citizens or citizens of a state belonging to the European Union.
 - **Citizens of a non-European Union State** must submit documents and qualifications in Italian or English or one of the additional languages, if any, indicated in Annex A, under penalty of exclusion from the selection or, as the case may be, non-assessment.
Documents and titles, originally in a different language, must be accompanied by a translation, made by the candidate under his or her responsibility, into Italian or English or any other language indicated in Appendix A. With reference to the dissertation only, the translation may be limited to an extended abstract.
 - **Citizens of a non-EU State regularly residing in Italy** may use declarations in lieu of certification only in respect of states, personal qualities or facts that can be certified or attested to by Italian public bodies, without prejudice to the special provisions contained in the laws and regulations governing immigration and the status of foreigners.
 - **Citizens of non-EU states authorised to reside in Italy** may use the aforementioned declarations in cases where they are produced pursuant to international conventions between Italy and the declarant's country of origin.

Applicants may also enclose with their application for assessment purposes their publications and any other qualification deemed useful to prove their qualification in relation to the research programme described in Annex A and to certify any research activity carried out in public and/or private entities (with the indication of the starting date and duration). The submission modalities are similar to those indicated in point 4 of the previous paragraph.

Only the qualifications possessed by the candidate on the date of submission of the application for selection and presented in accordance with Article 5 will be assessed.

Any exclusion from the selection procedure due to lack of eligibility requirements, absence of mandatory documents, failure to sign the application to take part in the selection or submission of the application in a manner other than that provided for in this call will be communicated to the parties concerned exclusively by email to the email address indicated in the application to take part in the selection.

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Art. 5

Registration for this selection will begin on May 30, 2024 at 2:00 pm (Italian time) and will end on June 14, 2024 at 2:00 pm (Italian time).

The application to take part in the selection must be completed, under penalty of exclusion, using the appropriate online procedure, available at <https://pica.cineca.it/>.

For those who do not already have a user account, the procedure involves a registration phase for the applicant, and a subsequent phase for completing the application online.

Once completed, the application must be signed in the manner (handwritten signature, with attached identity document, or digital signature) described in the online procedure, under penalty of exclusion from the selection. The application does not have to be signed if the above-mentioned online procedure is accessed using the Sistema Pubblico di Identità Digitale (SPID - Digital ID Public System). In the case of a handwritten signature, the applicant must upload the application to the system in its entirety. The information entered in the application form shall constitute a declaration in lieu of certification and affidavit, pursuant to Articles 46 and 47 of Presidential Decree no. 445/2000.

The qualifications referred to in Article 4 must be attached to the application in .pdf format. Individual files, in .pdf format, may not exceed 30MB in size.

It is not permitted to submit attachments to the application in the form of links to files residing on "online storage/file sharing" services or web pages. Reference may not be made to documents or publications submitted to this or other administrations or documents attached to the application for participation in another selection procedure.

The application for participation in the selection is automatically sent to the University of Udine with the final closure of the online procedure.

The University Administration:

- accepts no liability if it is impossible to read the submitted documentation in electronic format due to damaged files;
- does not accept or take into consideration qualifications or documents received in paper form or by any other means than those specified in this article.

The Administration accepts no liability in the event of incorrect indication by the candidate of his/her email address or in the event of failure or delay in communicating a change in the email address indicated in the application, nor for any digital transmission errors attributable to third parties, unforeseeable circumstances or force majeure.

Applicants are advised not to wait until the last few days before the deadline to submit their application. The University accepts no liability for any malfunctions due to technical problems and/or overloading of the communication line and/or application systems.

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Art. 6

The selection test takes place according to the modalities set out in Annex A.

The test will aim to ascertain the candidates' preparation, experience and research aptitude. It will consist of an assessment of the professional scientific curriculum, publications and titles submitted, and an interview, where applicable.

Failure of the candidate to attend the interview will be considered as withdrawal from the selection, whatever the cause.

Candidates who intend to avail themselves of the benefits provided for by Article 20 of Law no. 104 of 1992 (need for assistance, possible use of additional time for the performance of examination tests) in relation to their disability situation, must declare this and accompany the application with appropriate medical certification in order to allow the Administration to prepare in time the means and tools to guarantee the statutory benefits; failure to submit the medical certification exempts the Administration from any obligation in this regard.

Art. 7

The Competition Selection Board is identified in Annex A to this call, of which it forms an integral part. At its first meeting, the Board appoints the Chairperson and the Secretary taking the minutes, and establishes the criteria and procedures for assessing the qualifications and the interview, where applicable.

The results of the assessment must be made known to the parties concerned at the interview, where provided for.

The Board can attribute to the selection a total number of 100 points (one hundred hundredths). At the end of its work, the Board formulates the overall merit list based on the total marks obtained by each candidate and draws up the minutes of the competition operations.

The grant may be awarded, subject to the ranking list, to candidates who have obtained a minimum overall mark of 70/100 (seventy hundredths).

The Board's judgement is final on the merits.

The ranking list will be made public exclusively by publication on the University's official notice board; the outcome of the assessment will not be the subject of personal communication to candidates.

Those who do not declare their acceptance of the research grant and do not present themselves at the structure where the research activities are to be carried out to sign the contract by the deadline communicated by the same to the email address indicated by the candidate in the application shall forfeit their right to the research grant, except for health reasons or reasons of force majeure duly documented and promptly notified.

Candidates holding qualifications obtained abroad, if successful, must submit the following, if not already attached to the application:

- **For degrees issued by a country that is a party to the Lisbon Convention (<https://www.enic-naric.net/>), the following documentation:**
 - *Supplement* Diploma or similar certificate in English issued by the competent University.

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- "Certificate of Verification of Foreign Qualification - CIMEA" issued by CIMEA (Centre for Information on Academic Mobility and Equivalences) via the "diplome" service at <https://cimea.diplo-me.eu/udine/#/auth/login>
- **For degrees issued by a country not party to the Lisbon Convention (<https://www.enic-naric.net/>), one of the following options:**
 - Declaration of the on-site value of the qualification held and the certificate relating to the qualification with examinations and grades. The certificate in a language other than Italian or English must be accompanied by an official translation into one of those languages (certified by the competent diplomatic-consular authority or sworn at a court in Italy).
 - "Certificate of Comparability and Verification of Foreign Qualifications - CIMEA" issued by CIMEA (Centre for Information on Academic Mobility and Equivalences) via the "diplome" service at <https://cimea.diplo-me.eu/udine/#/auth/login>

If the aforementioned documentation is not available at the time of the conclusion of the contract, the candidate must prove that he or she has requested it and submit it as soon as possible; if it is not submitted within six months of the start of the contract, the candidate will forfeit the contract and will be required to repay any related sums received to date.

Art. 8

The research activity cannot be started before the contract defining the terms of the collaboration is signed.

The activity covered by the research grant must have the following characteristics:

- a) Be carried out in the context of the research programme covered by the grant and not be a purely technical support to the same.
- b) Close connection with the implementation of the research programme that is the subject of the relationship with the winner.
- c) Having a continuous and in any case temporally defined character, not merely occasional, and in coordination with the overall activity of the University.
- d) Performance in a condition of autonomy, within the sole limits of the programme prepared by the Head of the same, without predetermined working hours.

The research fellow is obliged to submit a detailed written report on the work carried out and the results achieved, together with the opinion of the scientific supervisor, to the reference structure within the deadlines laid down in the contract. The research fellow will also have to submit interim reports and time sheets if requested by the reference structure and/or the scientific supervisor.

The research fellow is bound to strict confidentiality regarding the data and information to which he/she becomes privy in the course of his/her research activity. At the request of the scientific coordinator, he/she will be required to sign an appropriate confidentiality agreement.

The industrial property rights to the results obtained by the research fellow in the performance of the research activity belong exclusively to the University, without prejudice to the moral right of the research fellow to be recognised as an author or inventor.

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The University reserves the right to revoke this call for competition for reasons of public interest, should the research project and/or the financial backing on which the research grant is based cease to exist. Should these causes arise after the contract has been signed, the University may terminate the contract without notice.

Art. 9

The following apply to the grant under this call:

- On tax matters, the provisions of Article 4 of Law no. 476 of 13 August 1984, as amended.
- On social security matters, the provisions of Article 2(26) et seq. of Law no. 335 of 8 August 1995, as amended.
- On compulsory maternity leave, the provisions of the Ministerial Decree of 12 July 2007.
- On sick leave, the provisions of Article 1(788) of Law No 296 of 27 December 2006, as amended.

During the period of compulsory maternity leave, the allowance paid by INPS pursuant to Article 5 of the Ministerial Decree of 12 July 2007 is supplemented by the University up to the full amount of the research grant.

The grant will be paid in monthly instalments in arrears.

Art. 10

The data collected as part of the procedure referred to in Article 5 is necessary for the proper management of the selection procedure, for the possible subsequent management of the research grant and purposes related to the management of the services provided by the University. The University of Udine is the Data Controller. At any time, the data subject may request access, rectification and, compatibly with the institutional purposes of the University, cancellation and restriction of processing or may object to the processing of his/her data. He/she can always lodge a complaint with the Italian Data Protection Authority. The full information is available on the University of Udine website in the "Privacy" section accessible from the home page www.uniud.it Direct Link: <https://www.uniud.it/it/pagine-speciali/guida/privacy>

Art. 11

For any matters not expressly mentioned in this call, reference is made to the relevant regulations in force cited in the introduction and to the "Internal regulations for the award of research grants pursuant to Law no. 240 of 30 December 2010" of the University of Udine issued by Rector's Decree no. 182 of 31 March 2021.

Art. 12

The official in charge of the proceeding is Dr. Sandra Salvador, Head of the Research Services Area of the University of Udine.

The reference office at the University of Udine is the "Area Servizi per la Ricerca - Ufficio Formazione per la Ricerca", Via Mantica 31 - 33100 Udine.

To request information on the call, please complete the following form available on the University of Udine website: https://helpdesk.uniud.it/SubmitSR.jsp?type=req&accountId=universityofudine&populateSR_id=42105

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Annex A

Responsabile scientifico della ricerca / Principal investigator:

Nome e cognome / Name and surname: Luca Geatti
Qualifica / Position: Ricercatore a tempo determinato / Researcher
Dipartimento / Department: Scienze Matematiche, Informatiche e Fisiche (DMIF) / Mathematics, Computer Science and Physics
Area MUR / Research field: 01 – Scienze matematiche e informatiche
Settore concorsuale e Settore scientifico disciplinare / Scientific sector: 01/B1; INF/01 - Informatica

Titolo dell'assegnio di ricerca / Topic of the research fellowship "assegnio di ricerca":

I bandi sono consultabili dal sito dell'Ateneo, del MUR e di Euraxess / The calls are available on the University, MUR and Euraxess websites

Testo in italiano:

Integrazione di tecniche di machine learning nella verifica a runtime.

Text in English:

Integration of machine learning techniques in runtime verification.

Obiettivi previsti e risultati attesi del programma di ricerca in cui si colloca l'attività dell'assegnista di ricerca / Foreseen objectives and results of the research programme performed by the research fellow "assegnista di ricerca":

I bandi sono consultabili dal sito dell'Ateneo, del MUR e di Euraxess / The calls are available on the University, MUR and Euraxess websites

Testo in italiano:

Il progetto di ricerca si pone come obiettivo lo studio e la sperimentazione dell'integrazione di tecniche di apprendimento automatico (machine learning) nella verifica a runtime. La verifica a runtime (o monitoring) è una serie di tecniche per il monitoraggio di un sistema, sia hardware che software, durante la sua esecuzione effettiva. Usate tipicamente nei contesti safety critical, cioè nei casi in cui un malfunzionamento può portare a gravi danni (economici, ambientali, ecc.) fino alla perdita di vite umane, queste tecniche prevedono la costruzione di un monitor, cioè di un dispositivo che viene affiancato al sistema e che rileva specifiche proprietà in tempo reale. Tali proprietà solitamente vengono espresse tramite l'uso di linguaggi formali, in particolare tramite la Logica Temporale.

Il punto fondamentale di queste tecniche di monitoraggio risiede nel fatto che il (codice del) monitor viene costruito in maniera totalmente automatica a partire da una formula logica (temporale) che esprime la proprietà che si vuole verificare.

Nonostante la crescita in termini teorici e pratici che queste tecniche hanno conosciuto negli ultimi decenni, un'importante limitazione che impedisce l'uso efficace ed efficiente di queste tecniche in contesti reali e di scala industriale rimane. Le tecniche di verifica a runtime forzano l'esperto di sistema a specificare tutti i requisiti che si vuole verificare prima della costruzione del monitor. Questo risulta in una forte restrizione per i seguenti motivi: (i) i sistemi moderni posseggono un tale livello di difficoltà che è impossibile conoscere tutti i possibili comportamenti del sistema; (ii) anche una piccola modifica del sistema può introdurre errori non previsti dalle proprietà; (iii) è fondamentale non solo identificare i problemi, ma soprattutto prevenirli (early failure detection), compito che risulta difficile o impossibile a priori, dato il punto (i).

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Questo progetto ha come obiettivo l'integrazione dei metodi di verifica a runtime con le tecniche di apprendimento automatico (machine learning) seguendo il framework proposto in [1], che prevede l'apprendimento continuo di nuove formule della logica temporale a fronte di un'analisi delle precedenti esecuzioni del sistema che hanno portato ad un fallimento. Questo consente alle nuove proprietà scoperte di essere più raffinate rispetto alle precedenti e di identificare un fallimento in minor tempo. Una caratteristica principale di questo approccio è l'interpretabilità, che viene garantita dall'uso e dalla manipolazione di formule logiche, che possono essere ispezionate da un esperto di sistema; questo è in diretto contrasto con le tecniche classiche per la early failure detection, come per esempio i metodi per la manutenzione predittiva (predictive maintenance), con le quali ottenere una spiegazione del risultato non è spesso possibile.

Il principale compito dell'assegnista sarà quello di estendere le funzionalità di tale framework secondo le seguenti direzioni:

1. estendere le funzionalità del framework delineato in [1] dalla sola anticipazione dei fallimenti (intesi come eventi catastrofici per il sistema) all'identificazione di anomalie (comportamenti non catastrofici che deviano dal comportamento nominale) e i cali di performance;
2. consentire l'uso di algoritmi per la generazione delle nuove formule che vadano oltre agli algoritmi genetici usati in [1], per esempio, tramite l'uso di graph neural networks.

In particolare, gli obiettivi di questo assegno di ricerca si articolano come segue:

- Mesi 1-2: Analisi dello stato dell'arte (in forma di report) delle tecniche per early failure detection con garanzie di interpretabilità. Inoltre, dovrà essere data importanza al confronto tra le varie tecniche di apprendimento automatico usate in questo contesto (algoritmi genetici, reti neurali a grafo, ecc.).
- Mesi 3-4-5: Sviluppo di metodi efficienti per la sintesi di formule temporali e confronto con l'approccio basato su algoritmi genetici, in particolare seguendo questi sotto-obiettivi:
 - studio di possibili codifiche di formule temporali tramite reti neurali a grafo, anche tramite lo studio delle tecniche di deep symbolic regression;
 - sperimentazioni di codifiche di automi (cioè grafi etichettati usati come rappresentazione alternativa delle formule logiche temporali) tramite reti neurali a grafo;
 - sperimentazioni di traduzioni di automi in formule logiche temporali.
- Mese 6: Analisi dello stato dell'arte (in forma di report) riguardante le tecniche, i vantaggi e gli svantaggi degli algoritmi per la anomaly detection (con garanzie di interpretabilità).
- Mesi 7-8-9: Investigazione di metodi per anomaly detection basati sull'uso di formule temporali, intesi come estensione delle funzionalità del framework in [1].
- Mesi 10-11-12: Implementazione della struttura generale del framework e interfacciamento con tool di verifica a runtime.

[1] Andrea Brunello, Dario Della Monica, Angelo Montanari, Nicola Saccomanno, and Andrea Urgolo. Monitors that learn from failures: Pairing STL and genetic programming. *IEEE Access*, 11:57349–57364, 2023.

Text in English:

The research project aims to study and experiment with the integration of machine learning techniques in runtime verification. Runtime verification (or monitoring) is a series of techniques for monitoring a system, both hardware and software, during its actual execution. Typically used in safety-critical contexts, where malfunction can lead to serious damages (economic, environmental, etc.) including loss of human lives, these techniques involve the construction of a monitor, a device that is attached to the system and detects specific properties in real-time. These properties are usually expressed using formal languages, particularly through Temporal Logic.

The fundamental point of these monitoring techniques lies in the fact that the (code of the) monitor is built entirely automatically starting from a logical (temporal) formula that expresses the property to be verified.

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Despite the theoretical and practical growth these techniques have experienced in recent decades, an important limitation remains, hindering their effective and efficient use in real-world and industrial-scale contexts. Runtime verification techniques force the system expert to specify all the requirements to be verified before constructing the monitor. This results in a strong restriction for the following reasons: (i) modern systems possess such a level of complexity that it is impossible to know all possible system behaviors; (ii) even a small system modification can introduce errors not foreseen by the properties; (iii) it is essential not only to identify problems but, especially, to prevent them (early failure detection), a task that is difficult or impossible beforehand given point (i).

This project aims to integrate runtime verification methods with machine learning techniques following the framework proposed in [1], which involves continuous learning of new temporal logic formulas based on an analysis of previous system executions that led to failure. This allows newly discovered properties to be more refined than previous ones and to identify failure in less time. A key feature of this approach is interpretability, which is ensured by the use and manipulation of logical formulas that can be inspected by a system expert; this is in direct contrast to classical techniques for early failure detection, such as predictive maintenance methods, where obtaining an explanation of the result is often not possible.

The main task of the grantee will be to extend the functionalities of such framework according to the following directions:

1. extend the functionalities of the framework outlined in [1] from solely anticipating failures (understood as catastrophic events for the system) to identifying anomalies (non-catastrophic behaviors deviating from nominal behavior) and performance drops;
2. enable the use of algorithms for generating new formulas beyond the genetic algorithms used in [1], for example, through the use of graph neural networks.

In particular, the objectives of this research grant are articulated as follows:

- Months 1-2: Analysis of the state of the art (in the form of a report) of techniques for early failure detection with interpretability guarantees. Additionally, importance should be given to comparing various machine learning techniques used in this context (genetic algorithms, graph neural networks, etc.).
- Months 3-4-5: Development of efficient methods for synthesizing temporal formulas and comparison with the genetic algorithm-based approach, particularly following these sub-objectives:
 - study of possible encodings of temporal formulas through graph neural networks, also through the study of deep symbolic regression techniques;
 - experimentations with automata encodings (i.e., labeled graphs used as an alternative representation of temporal logical formulas) through graph neural networks;
 - experimentations with the translation of automata into temporal logical formulas.
- Month 6: Analysis of the state of the art (in the form of a report) regarding techniques, advantages, and disadvantages of algorithms for anomaly detection (with interpretability guarantees).
- Months 7-8-9: Investigation of methods for anomaly detection based on the use of temporal formulas, intended as an extension of the functionalities of the framework in [1].
- Months 10-11-12: Implementation of the general structure of the framework and interfacing with runtime verification tools.

[1] Andrea Brunello, Dario Della Monica, Angelo Montanari, Nicola Saccomanno, and Andrea Urgolo. Monitors that learn from failures: Pairing STL and genetic programming. *IEEE Access*, 11:57349–57364, 2023.

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Struttura dell'Università di Udine presso la quale verrà sviluppata l'attività di ricerca / Department or other structure of the University of Udine where research activities will be carried out:

Dipartimento di Scienze Matematiche, Informatiche e Fisiche (DMIF). / Department of Mathematics, Computer Science and Physics.

Nota / Note: In base alle esigenze del progetto PNRR su cui grava il finanziamento, l'assegnista di ricerca potrà dover svolgere parte delle attività presso altre Università e Istituzioni coinvolte nel medesimo progetto. / Based on the needs of the PNRR project that finances the research grant, the research fellow may have to carry out part of the activities at other universities and institutions involved in the project.

Importo dell'assegno di ricerca (al lordo oneri carico assegnista) / Total grant gross for the research fellowship:

€ 20.266,98

Durata dell'assegno di ricerca / Duration of the research fellowship "assegno di ricerca":

12 mesi / months

Finanziamento / Financed by:

La copertura finanziaria graverà sul progetto Ecosistemi dell'Innovazione, PNRR – Missione 4: Istruzione e ricerca, Componente 2: Dalla ricerca all'impresa, Investimento 1.5: Creazione e rafforzamento di "Ecosistemi dell'innovazione", costruzione di "leader territoriali di R&S", finanziato dall'Unione Europea – NextGenerationEU. Progetto ECS0000043 (Area tematica: Digital, Industry, Aerospace) Interconnected Nord-Est Innovation Ecosystem (iNEST). Avviso MUR n. 3277 del 30/12/2021, Decreto Direttoriale di concessione del finanziamento n. 1058 del 23/06/2022, Atto d'Obbligo e di Accettazione firmato in data 01/08/2022, CUP G23C22001130006.

Requisiti di ammissione / Minimum qualifications necessary:

Possesso di un diploma di laurea vecchio ordinamento (ante decreto 3 novembre 1999 n. 509) o di laurea specialistica/magistrale (ex decreto 3 novembre 1999 n. 509 e decreto 22 ottobre 2004 n. 270) o titolo equivalente conseguito all'estero / Possession of a University degree obtained before Decree n. 509 of 3 November 1999 or specialistic/Master's degree (post decree n. 509 of 3 November 1999 and decree n. 270 of 22 October 2004) or equivalent degree obtained abroad.

DECRETO RETTORALE

Modalità di presentazione della documentazione oggetto di valutazione / Arrangements for the submission of documents:

La modalità di presentazione della documentazione oggetto di valutazione è specificata all'art. 4 del bando. / The way of presenting the documentation under evaluation is specified in art. 4 of the present notice.

Ai fini valutativi, i candidati potranno presentare le pubblicazioni e ogni altro titolo ritenuto utile a comprovare la propria qualificazione in relazione al programma di ricerca descritto nell'Allegato A, nelle seguenti lingue: / For evaluation purposes, candidates may present publications and any other qualifications deemed useful to demonstrate their qualification in relation to the research program described in Attachment A, in the following languages:

- Italiano / Italian
- Inglese / English

Procedura selettiva / Competition procedure:

Valutazione per soli titoli. / Assessment of qualifications only.

Commissione giudicatrice / Examining Board:

Nome e Cognome	Qualifica	SSD	Università
Membri Effettivi / Permanent members			
Luca Geatti	RTD	INF/01	Università degli Studi di Udine
Angelo Montanari	PO	INF/01	Università degli Studi di Udine
Andrea Brunello	RTD	INF/01	Università degli Studi di Udine
Membro Supplente / Temporary member			
Roberto Pagliarini	RTD	INF/01	Università degli Studi di Udine