# University of Trento
# PhD Programme in Industrial Innovation
# Jointly run with FBK

## Ciclo 35/35<sup>th</sup> Cycle
## A.Y. 2019/2020

BORSE A TEMATICA VINCOLATA/RESERVED SCHOLARSHIPS

## SCHOLARSHIPS

| A | Artificial Intelligence for Digital Transformation | University of Trento and FBK, in collaboration with Dedagroup SpA |
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| B | Artificial Intelligence for Clinical Decision Support | University of Trento and FBK, in collaboration with Exprivia SpA |
| C | ORS AI Platform | University of Trento and FBK, in collaboration with ORS GROUP |
| D | Laser-beam cutting modeling and testing for improved quality and high-demanding structural applications | University of Trento and Adige Sys SpA |
| E | Maintenance optimization in the highway engineering sector | University of Trento and Autostrade del Brennero SpA (A22) |
| F | Vehicle Dynamic models for real-time applications and training of artificial drivers | University of Trento and AnteMotion Srl |
| G | Assisting docking manoeuvre simulation for pleasure craft | University of Trento and ZF Padova srl |
| H | Ontology-driven support to fault diagnosis of manufacturing machines based on service mail flows and repair records | CNR and BLM Group – Adige SYS |

## PhD EXECUTIVE

| AE | Topic 1: Dynamic authorization building on Attribute-based Access Control approaches.<br>Topic 2: Dynamic authorization and usage control for mobile device operating systems.<br>Topic 3: Policy management, editing, evaluation, symbolic execution and impact analysis of dynamic authorization policies.<br>Topic 4: Distributed Ledger, Blockchain and Smart-Contract technologies | Huawei Technologies Duesseldorf GmbH |
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| BE | Machine learning meets finance: a robust method to allocate wealth to different trading signal | Resonanz Capital GbmH |

Scholarship A

| Topic | Artificial Intelligence for Digital Transformation |
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| **FBK**, in collaboration with Dedagroup SpA | |
| **Contacts** | **Marco Pistore** |

**Synthetic description of the activity and expected research outcome**

Digital technologies play an ever increasing role in all aspects of human society; this induces a wide range of changes, collectively referred to as Digital Transformation, that, far from being only technological, also cover cultural, organizational, social, managerial aspects of our life. Artificial Intelligence is a key technology for digital transformation, thanks to its capability to extract information and knowledge from data; this requires the capability to open, analyze and exploit all data available on a given phenomenon, data that are often highly heterogeneous, scattered, and coming from different sources (e.g. open, sensor, free, closed, linked data).

This thesis will concentrate on developing a data-driven computational framework, based on AI approaches, able to perform data analysis and prediction in the setting just described. The framework will be developed in the scope of the Digital Hub, a digital platform jointly developed by Dedagroup and Fondazione Bruno Kessler to address digital transformation in different application domains, including Public Administration, Digital Finance, Digital Industry. The validation of the framework will be performed addressing problems in these application domains, by exploiting the data sets and services integrated in the Digital Hub.

Scholarship B

| Topic | |
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| | Artificial Intelligence for Clinical Decision Support |

**FBK**, in collaboration with Exprivia SpA

| Contacts | Claudio Eccher |
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**Synthetic description of the activity and expected research outcome**

This PhD work will design and develop a new tool able to support clinical decisions based on evidences to be activated in multiple clinical contexts and workflows. The system will exploit the information available in repositories and clinical systems to create a multidimensional view of patient, infer from this model possible consequences and suggest reactions. Inferential models will be based on predefined pathways as well as paths created by AI, machine learning and process mining algorithms adapting to the evolving patient conditions. The adoption of digital tools in health care is driven by different requirements, e.g., the need to simplify collaboration, create logs of actions for legal purposes and support clinical decisions and workflow. The use of electronic clinical information to evaluate human decisions against predefined protocols or statistically known evolution patterns is still largely underexploited. Few software tools able to support human decisions in specific clinical domains exist on the market, but no currently available solution is able to take advantage of the enormous amount of information available in the healthcare systems to extensively and transparently support clinical decisions and pathways. This PhD thesis will study, design and implement an intelligent component, integrated in a complex clinical products solution, able to monitor every useful information to obtain two important results:
- A real-time match of patient conditions against configured pathways models able to recommend (and synchronize) actions introducing a different perspective in applications (M2M) and humans (M2H) collaboration
- A fluid and continuous enrichment of statistical and knowledge models through AI-based techniques able to identify clinical conditions and propose advices, such as recommending protocols and clinical actions, computing probabilities of the outcomes, identifying relevant adverse events, etc. The key problems to be solved are:
-        Introduce new and more specific ways to represent patient condition as the result of selected information
Introduce new ways to represent multidimensional evolving protocols for managing clinical conditions
-        Integrate Artificial Intelligence-based tools to support medical decisions
-        Develop an effective human interface to allow the easy use of the above functions
The approach relies on the efficacious combination of AI and business process management techniques. The application of these techniques to the healthcare is of great interest because of the peculiarities of the domain, characterized by i) need of flexibility in the care pathway execution, (e.g., for dealing with comorbidities), ii) availability of a great amount of clinical data about the patient and similar cases, which should be exploited to learn from previous experience to modify the constraints and the sequence of future actions, and iii) the requirement to let each decision to the doctor, who must have all the information on the patient easy to read and interpret. Dealing with and solving these problems in a complex domain can advance the state of the art in the research field of combining logical reasoning, machine/deep learning and process representation and execution. Finally, the implementation of this approach in a component designed to be used in the everyday practices can open the way for the evaluation of these techniques in real clinical settings, thus giving substantial feedback to the academic research. The academic outcomes will include publications and participation in relevant academic events. The beneficiary of the scholarship will be included in the EIT Digital I&E Education course,

where he/she will receive training on aspects of entrepreneurship and innovation through participation in four courses organised by the Doctoral Training Center of EIT Digital. The candidate will also be required to carry out from 3 to 6-month study or research period abroad, within the research theme. In addition, the grant beneficiary must obtain a Business Development Experience at EXPRIVIA where scientific work will be integrated into entrepreneurship and innovation activities.

**Ideal candidate (skills and competencies):**
The candidate should possess at least basic knowledge on symbolic and machine learning Artificial Intelligence techniques.

Scholarship C

| Topic | ORS AI Platform |
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**FBK**, in collaboration with ORS GROUP

| Contacts | Bruno Lepri |
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**Synthetic description of the activity and expected research outcome**

The focus of this three-years program is to concentrate on the algorithms of the ORS AI Platform and to investigate and leverage on new innovate approaches.
The candidate will have the unique opportunity to explore different domains (Industry, Retails, Energy and Finance) being directly trained by very experienced professionals. He/she will be fostered to compare different techniques across all sectors leading to consolidate all new findings with very strong and real cases.
Here is a possible plan to be agreed with the candidate according to the proven skills:
• YEAR 1/2
o Investigate new approach to the predictive analyses with a focus on demand planning (in all domains)
o Contribute to the ORS Analytics platform with a focus on customer data market analysis (in retails)
• YEAR 2/3
o Optimization and scheduling problems and programming (in all domain)

**Ideal candidate (skills and competencies):**

The ideal candidate for this program will be part of the R&D team and has the following skills:
• Good knowledge in one or more programming languages such as C#, Python or R
• Good knowledge in statistics and Machine Learning techniques
• Good knowledge in NLP (Natural Language Processing)
• Good knowledge of optimization techniques (scheduling will be considered an added value)
• Experience in handling highly complex algorithm, mathematical programming and/or combinatorial optimization
• Strong attitude to investigate new solutions and explore new A.I. applied approaches
• Ability to work autonomously as well as in team
• Good working English knowledge

Scholarship D

| Topic | Laser-beam cutting modeling and testing for improved quality and high-demanding structural applications |
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| **University of Trento and Adige Sys SpA** | |
| Contacts | Paolo Scardi and Oreste Bursi |

**Synthetic description of the activity and expected research outcome**

Laser cutting is a modern and effective technology to complement or even replace well-established mechanical and thermal processes in the manufacturing of mechanical and structural components. Nowadays the cutting of metallic materials is included in the pipeline of several industrial production process, but while benefits in terms of production time, cost and quality are apparent, many aspects are still to be explored. In particular, the tuning of process parameters that define the cutting quality, both from a geometrical and a metallurgical viewpoint, are still the subject of scientific and industrial research, especially in the field of structural steels subjected to high-cycle fatigue. In this specific context, Eurocode 3 Part 1-9 and Part 1-12 demand a thorough study on the modifications induced by the laser process on structural steels widely used in construction.

The present project is aimed at developing a modelling tool to guide technologists in the use of the laser cutting technology, to optimize typical process parameters according to specific geometry and compositional requirements of structural components, while fulfilling all prescriptions of the cited Eurocode. In this, the student will be involved either in experimental work, to carry out standard as well as advanced tests on materials and on structural joints, and in finite element (FE) analyses, mainly at the material level, to model the thermomechanical aspects of the laser cutting. This work involves on one side for a deep understanding of the laser cutting technology, where the student can profit of the valuable competences of the proposing company, and on the other side exploiting the tools and skills available at the University of Trento to study the effect of the cutting process on mechanical fatigue behaviour, and to develop original FE models. It is therefore appropriate that candidate demonstrate some background knowledge in mechanical engineering topics, including FE modelling as well as basic metallurgical concepts of ferrous alloys.

Staff supporting the research work at the Department of Civil, Environmental & Mechanical Engineering (DICAM), University of Trento, includes the Tutor's group, thus Prof. Paolo Scardi and Dr. Mirco D'Incau, and the laboratory od Structural Engineering, led by Prof. Oreste S. Bursi, with the support of the many technicians and of Dr Gabriele Zanon.

Scholarship E

| Topic | **Maintenance optimization in the highway engineering sector** |
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| **University of Trento and Autostrade del Brennero SpA (A22)** | |
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| Contacts | **Matteo Brunelli** |
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**Synthetic description of the activity and expected research outcome**

More and more often, maintenance of plans, systems and infrastructures has a deep impact on the perceived quality of a product or a service. If on one hand there is the need to contain the cost, on the other there is the necessity of having safe and reliable assets. From this, stems the necessity of an intelligent and careful planning of maintenance activities.

In this context, the doctoral candidate will work in cooperation with Autostrada del Brennero S.p.A. (A22) in the field of reliability engineering to develop and apply innovative methods for risk assessment and mitigation in civil engineering. In particular, among other aspects, the research will relate to the (i) optimal choice and (ii) timing of different maintenance activities on physical assets of a motorway such as pavement, bridges and viaducts.

Although the problems stem from civil engineering, the methodology used in the research will, to a large extent, be based on operations research methods, such as decision analysis and mathematical optimization.

**Ideal candidate (skills and competencies):**
The candidate is expected to have a solid background in civil engineering or a strictly related field. Additionally, the candidate shall demonstrate a sufficient mathematical maturity and familiarity with at least one computational programming language. Further knowledge on risk analysis and operations research will be acquired during the studies.
Proficiency in both Italian and English is required too.

Scholarship F

| Topic | Vehicle Dynamic models for real-time applications and training of artificial drivers |
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| **University of Trento and AnteMotion Srl** | |
| Contacts | Francesco Biral |

**Synthetic description of the activity and expected research outcome**

Simulation tools are a key element in the design and analysis of performance of modern cars not only to predict and evaluate their dynamic behavior but also to understand how they interact with control units and intelligent systems that may take over the control of the vehicle such as autonomous driving functions. These analyses are quite often done with the real hardware in the loop (HIL) therefore the vehicle dynamic model has to be solved in real-time with typical 1 millisecond time step. Additionally, dynamic accuracy of the model is of great importance to derive realistic prediction of the vehicle and control system performance.

Another key feature of modern simulation tools is the availability of virtual/artificial drivers able to control them up to the handling limits in order to allow generation of thousands of simulation to explore the behavior of the system in different driving scenarios. Therefore Artificial/virtual drivers have to be able to drive a variety of vehicles with different dynamic characteristics and training procedures are envisaged to achieve this skill. Regardless the architecture and the methodology used to develop the artificial driver, it has to use some sort of dynamic model that represents the vehicle behavior he is controlling. It is a sort of "internal model" (or set of models) of the vehicle dynamic behavior.

The objective of this research is to develop vehicle dynamic models both 1) as virtual prototypes of the real car and 2) as internal "internal vehicle" models to be used by the artificial drivers.

We expect that the first model is developed using standard multibody methods based on the symbolic approach but with an object oriented view possibly using Modelica based tools such as MapleSim and Maple. The model has to be flexible and extendible in the sense that I can also integrated subsystems modelled also with neural networks if necessary and being able to include various driveline architectures, suspension systems and tyre models. An experimental validation plan has also to be foreseen to evaluate the model accuracy.

The second set of vehicle models will be reduced models able to predict the virtual prototype model behavior on a desired extent. Here various methodologies will be investigated including neural network based approaches.

One last topic is the vehicle identification parameters from experimental data: the use of optimization techniques derived from neural network training algorithms will be investigated.

**Ideal candidate (skills and competencies):**
The candidates should have basics knowledge of dynamic system modelling, numerical methods to solve differential equations and some basic knowledge of C programming.

Scholarship G

| Topic | Assisted docking manoeuvre simulation for pleasure craft |
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| **University of Trento and ZF Padova srl** | |
| Contacts | Paolo Bosetti |

**Synthetic description of the activity and expected research outcome**

Development of a mathematical simulation model for the assisted docking manoeuvre based on:
1)      detection and identification of mooring spot
2)      definition of optimum mooring path in function of environmental constraints (wind, stream, relative position of craft)
3)      detection of any obstacle on the path
4)      activation of alternative path to avoid collision

Scholarship H

| Topic | Ontology-driven support to fault diagnosis of manufacturing machines based on service mail flows and repair records. |
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| **CNR e BLM Group – Adige SYS** | |
| Contacts | **Nicola Guarino** |

**Synthetic description of the activity and expected research outcome**

This research work is the result of a joint investment of ISTC-CNR Laboratory for Applied Ontology and Adige SpA. Adige is a company of BLMGroup, an Italian leading industrial group producing high-end machines devoted to work on metallic pipes and profiles, by laser-cutting, sawing and bending. Adige is located in the province of Trento, the sister company AdigeSYS is also located in the province of Trento, and the headquarter of the group, BLM, is located in Lombardy.

Working together with the company's maintenance experts, the PhD candidate is expected to do an ontological analysis of the maintenance process, focusing on the diagnosis of technical malfunctioning, and leveraging on knowledge to be extracted from service mail flows and repair records. The work will include the development of a repair and diagnosis ontology in the specific domain, and an analysis of the ways such ontology, properly integrated within the broader service management system, may reduce the costs and increase the quality of the diagnosis and repair process.

On the scientific side, the candidate will learn how to model industrial scenarios (with a focus on maintenance) using rigorous ontological methodologies, working side by side with mechanical engineers and ontology experts.

**Ideal candidate (skills and competencies):**
Master in mechatronics, mechanical engineering, management/logistics engineering, computer science.

AE – PhD Executive

| Topics | **Topic 1:** research in improving dynamic authorization building on Attribute-based Access Control approaches for Big Data, Cloud and IoT (Internet of Things).<br>**Topic 2**: research in improving dynamic authorization and usage control for current (e.g. Android) and new mobile device and media pad operating systems and smart applications.<br>**Topic 3**: research in advance policy management, policy editing, policy evaluation, policy evaluation simulation, symbolic execution and impact analysis of dynamic authorization policies for Attribute Based Access control and Usage Control policies.<br>**Topic 4**: Research on innovative algorithms in the field of Distributed Ledger, Blockchain and Smart-Contract technologies in order to improve the secure sharing, analysis and validation of information such as data access logs or security incident reports. |
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| **Reserved to Huawei Technologies Duesseldorf GmbH employee** | |
| **Contacts** | **Bruno Crispo** |

**Synthetic description of the activity and expected research outcome**

**Topic 1**: research in improving dynamic authorization building on Attribute-based Access Control approaches for Big Data, Cloud and IoT (Internet of Things). This may include
- developing and implementing new dynamic authorization architectures that leverage and extend big-data authorization schemes (e.g. Apache Ranger),
- improving the structure and life-cycle of dynamic authorization policies,
- improving auditability and traceability of dynamic authorizations in large scale distributed environments.

**Topic 2**: research in improving dynamic authorization and usage control for current (e.g. Android) and new mobile device and media pad operating systems and smart applications.
This may include
- developing and implementing new dynamic authorization architectures for mobile operating systems and media pads that leverage and extend attribute based access control (ABAC) and usage control (UCON),
-      improving the structure, management, usability and life-cycle of dynamic authorization policies,
- improving auditability and traceability of dynamic authorizations in distributed mobile cloud and IoT / Smart Home environments.

**Topic 3:** research in advance policy management, policy editing, policy evaluation, policy evaluation simulation, symbolic execution and impact analysis of dynamic authorization policies for Attribute Based Access control and Usage Control policies.  This may include
- innovations in improving design and development of advanced policy management leveraging on administrative policy management and delegation models (such as the administration profile of XACML v3.0) standard;
- innovations in policy modeling and symbolic execution of policies
- innovations in improving the analysis of if and how an authorization policy meets privacy or security requirements
- innovations in improving the analysis of the impact of policy updates or policy-based reaction to environmental changes.
- innovations in policy analysis enabling the more efficient combination of policies and resolution of policy conflicts in the presence of administrative delegation

Topic 4: Research on innovative algorithms in the field of Distributed Ledger, Blockchain and Smart-Contract technologies in order to improve the secure sharing, analysis and validation of information such as data access logs or security incident reports

BE – PhD Executive

| Topic | Machine learning meets finance: a robust method to allocate wealth to different trading signals |
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| **Reserved to Resonanz Capital GbmH employee** | |
| Contacts | Sandra Paterlini |

**Synthetic description of the activity and expected research outcome**

The recent improvement in hardware, data availability and amount, and the evolution of machine learning tools have sparked an increase in the interest towards quantitative investing. Mining data to find new trading signal (also referred to as alphas) has become simpler and translated into an exponential increase in the number of available trading signals. While the benefits of this process are evident, the drawbacks have not yet received much attention in the financial academic and practitioner's community.

The objective of this research is to highlight all the issues related to this new landscape and, expanding on the existing research, to propose a robust methodology to tackle the problem of extracting trustable signals from a large number of correlated and potentially ephemeral trading signals.