IRP ADONIS:
Diagnosis and intelligent control approaches for more ecological systems

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Abstract - The international research project (IRP) ADONIS, 2020-2024, focuses on the diagnosis and intelligent control of systems. It groups researchers from four partner organizations and universities: CNRS France, CNRS Lebanon, Université de technologie de Compiègne (UTC) and Lebanese University (UL), with common interests and the desire to collaborate together in the areas of control, data analysis, data uncertainties, and this in several study domains, such as biomedical systems, transport systems, and robotic and mechatronic systems. Three UTC/CNRS research units are involved in this IRP on the French side: Heudiasyc (UMR 7253), Roberval (FRE 2012) and BMBI (UMR 7338); as well as the CRSI (Centre de recherche scientifique en ingénierie) on the Lebanese side. About forty researchers are involved in this project, in the French and Lebanese teams.

Keywords: Data uncertainty, Security, Control, Diagnosis, Safety, Maintenance, Decision, Biomedical systems, Transport systems, Robotic and mechatronic systems.

I. INTRODUCTION

After many years of collaboration between the partner establishments of this project, and in particular between UTC and UL since 1997, the international IRP ADONIS project aims to consolidate and perpetuate this collaboration, to widen its scope to new research themes , and to increase its attractiveness and visibility.

This research project focuses on the diagnosis and intelligent control of systems. In fact, systems (industrial, biomedical, civil, transport infrastructure, etc.) are becoming more and more complex and vulnerable to faults, defects and failure in the operation of components, equipment and controllers. This can have serious, undesirable consequences, such as damage to equipment.

They can then represent a threat to human lives, for the environment and can have harmful consequences on the economy. In addition, due to the complexity of the systems, the diagnosis of faults or abnormal / pathological behaviors requires more efficient processing and decision-making tools.

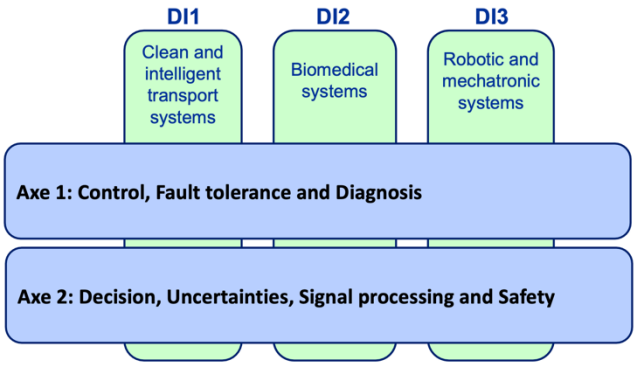

Figure 1. Thematic axes and engineering domains of the IRP ADONIS project

The objectives of this project in diagnosis and intelligent control allow to respond to the various constraints to which modern systems are subject: to be able to operate for an increasingly long period, while respecting several criteria on safety, efficiency and respect of the environment.

In this context, the research work of IRP ADONIS, in collaboration between the French and Lebanese teams, revolves around two theoretical axes, and three engineering fields, as presented in Figure 1.

Various themes are studied within the framework of this project, at the intersection of these axes of research and the mentioned engineering fields. Several of these themes address economic and ecological issues, as well as system safety, and will be mentioned later.

This different researches in different fields rely heavily on technological platforms, with partners in France and Lebanon (Fig. 2).

Figure 2. Technological platforms supporting IRP ADONIS research work

II. IRP ADONIS RESEARCH TOPICS

Several research themes are studied around biomedical systems, in collaboration between the BMBI laboratory and the UL, such as the following:

- Reliable and early diagnosis of preterm birth [1].
- Inverse methods applied to HD-EMG signals for the study of neuromuscular aging [2].
- Processing and analysis of the HRV signal for e-health applications [3].

Figure 3. Applications around biomedical systems

On the other hand, several themes dealing with safety, security, control and diagnosis, with various applications including robotic systems and transport systems, are developed between the Heudiasyc laboratory and UL. Below are some of these research topics:

- Intelligent, reliable and secure systems for the management of emergency and crisis situations. IoT (Internet of Things) networks are considered for crisis management in the medical field (monitoring of patients) and in the railway field (monitoring of fires or passenger incidents).
- Decision architecture and trajectory planning for autonomous electric vehicles, with energy reduction [4]. The decision in a multi-vehicle system aims to save energy and to ensure the safety and manage some complex driving maneuvers.
- Fault tolerance of UAV systems [5][6].
- Early diagnosis of industrial machines to detect mechanical defaults.
- Optimization of the availability of multi-state systems in the presence of random and epistemic uncertainties, to choose the best configuration for the system in terms of availability, cost and inaccuracy [7].

Figure 4. Application around autonomous electric vehicles

In addition, themes around electrical machines, batteries and power electronic systems are studied between the Roberval laboratory and UL, including:

- Mechanical and thermal modeling of a synchro-reluctant machine for a vehicle application [8].
- Development and implementation of a state-of-charge observer for a Li Ion battery on a real-time FPGA calculator.
- Study of the interaction of static converters on a shared DC bus [9].
- Non-contact temperature measurement method, integrated in the rotor of a rotating machine, using fiber Bragg gratings [10].
- Temperature mapping inside a rotating machine based on fiber optic sensors.

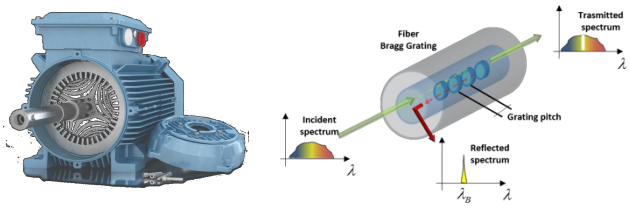

Figure 5. Applications around electrical machines and fiber optic sensors

III. COLLABORATION HISTORY

The project follows a long collaboration marked by several important events, on the research and training aspects, since 1997:

- **1997**: General agreement (UTC-UL), renewed in 2002, 2009 and 2016.
- **1999-2020**: Cursus relocated to UL from the UTC Master's in "Industrial Control" which became "Robotics and Intelligent Systems" in 2016, (267 graduates).
- **2008**: Joint supervision thesis (cotutelle) program between UL and the UT/INSA network.
- **2012**: Framework agreement for international co-supervision (cotutelle) of UL-UTC thesis: 18 theses.
- **2014**: Cursus relocated to UL for the UTC Master's in "Technology of Industrial Medical Systems" (24 graduates between 2014 and 2017).

IV. CONCLUSION AND PERSPECTIVES

This paper presents the context and objectives of the international research project IRP ADONIS, in collaboration between CNRS and Université de technologie de Compiègne in France, and the Lebanese CNRS and the Lebanese University in Lebanon. This project concerns the diagnosis and intelligent control of systems. Many themes are developed around safe and intelligent systems, addressing ecological issues in several areas such as transport and health.

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