Biomedical MicroRobotics

David FOLIO

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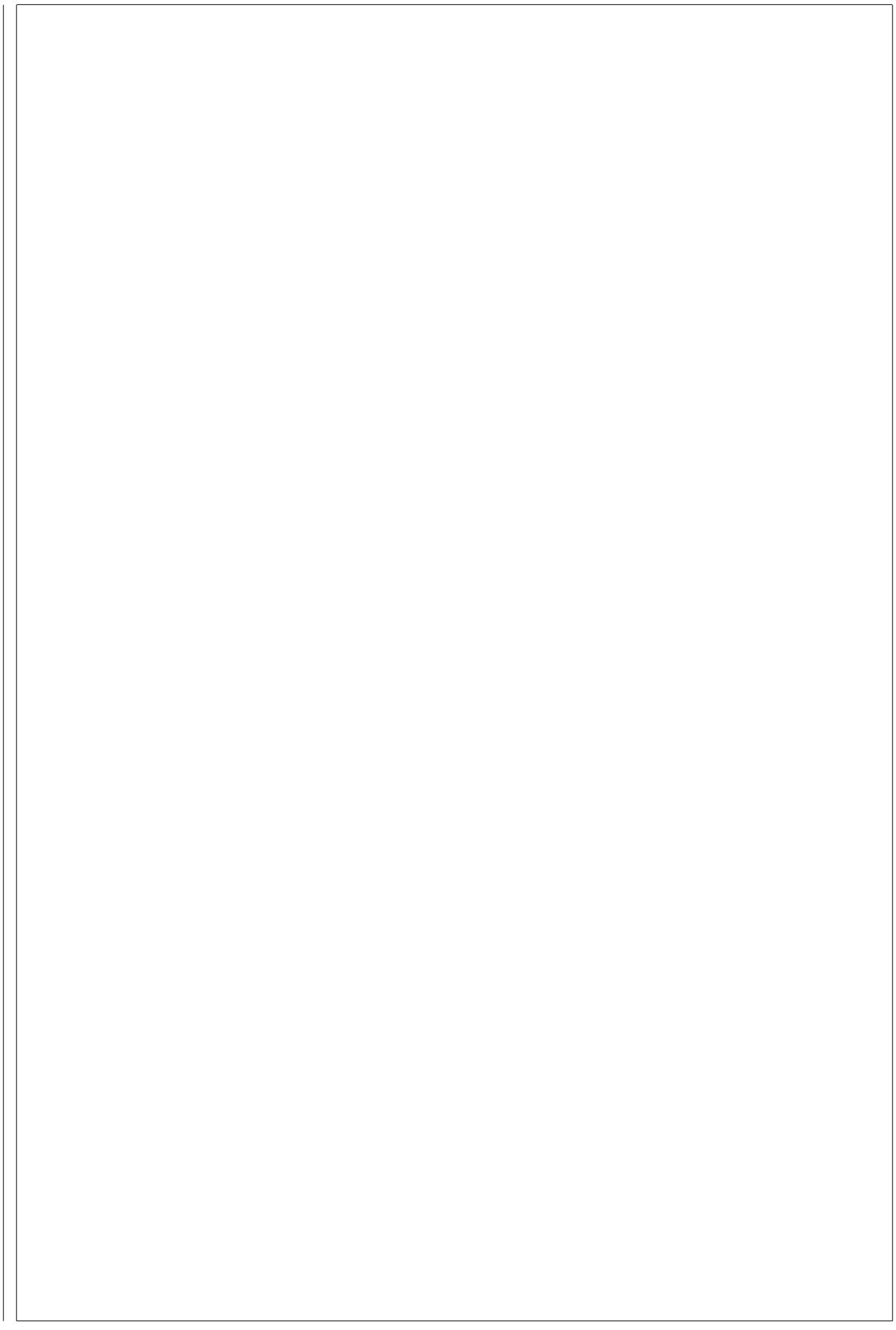
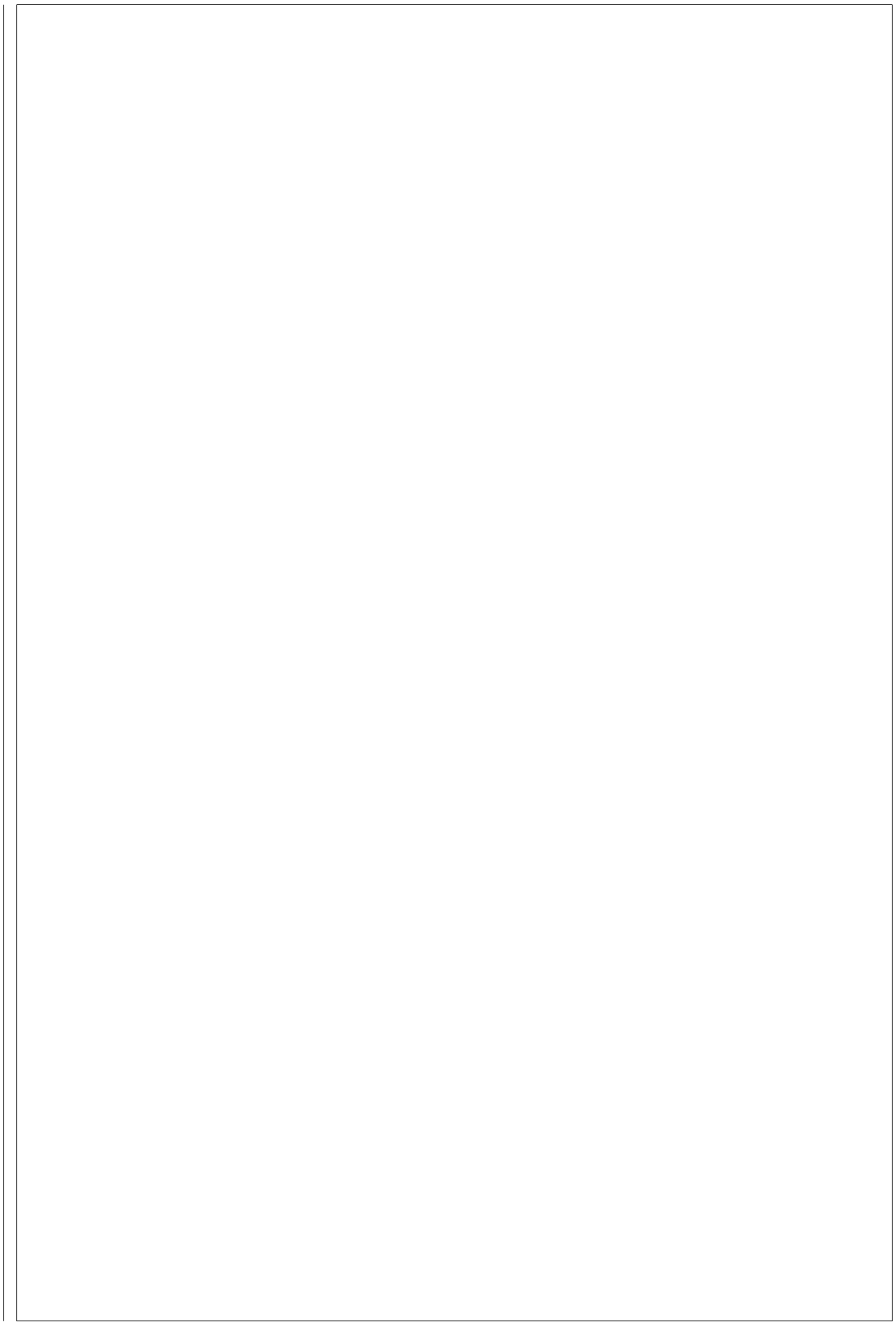
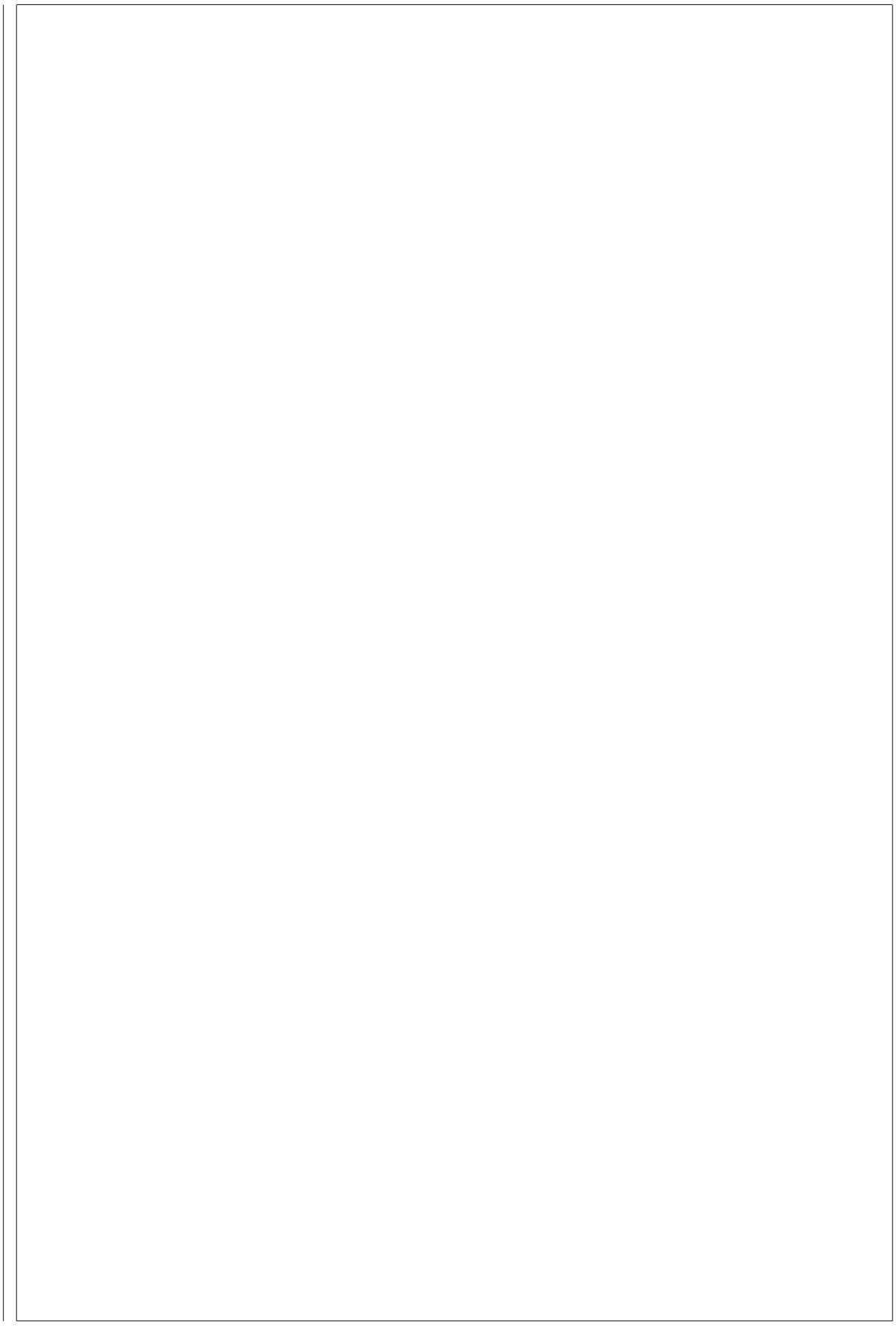


Contents



List of Figures



List of Tables

Chapter I

Context of Activities

This chapter introduces the various activities that I have conducted since I started as Associate Professor in 2008. It first starts with an overall overview of my career, that sets the context in which my works was carried out. As in any faculty position, my work encompasses several activities mainly related to teaching and research. The organization of these tasks are then presented in section I.2. This integrates the articulations of the teaching, research, supervisions and collaboratives works in a general framework synergy. This chapter largely refers to the appendices A and B that include a long version of my resume, and the list of my publications respectively.

I.1 Career overview

I.1.1 Doctorate degree and post-doctorate

I defended my PhD in Robotics in 2007 within the Robotics, Action, and Perception (RAP) group of the Laboratory for Analysis and Architecture of Systems (LAAS[1]), CNRS[2], under the supervision of Viviane Cadenat, Associate Professor at Paul Sabatier University in Toulouse. My PhD thesis dealt with the design of multi-sensor based control strategies allowing a mobile robot to perform vision-based tasks amidst possibly occluding obstacles. We have first proposed techniques able to fulfill simultaneously the two previously mentioned objectives. However, avoiding both collisions and occlusions often over-strained the robotic navigation task, reducing the range of realizable missions. This is the reason why we have developed a second approach which lets the visual features loss occurs if it is necessary for the task realization. Using the link between vision and motion, we have proposed different methods (analytical and numerical) to compute the visual signal as soon it becomes unavailable. We have then applied them to perform vision-based tasks in cluttered environments, before highlighting their interest to deal with a camera failure during the mission.

Between 2007 and 2008, I joined the Lagadic team at Inria Rennes-Bretagne Atlantique as a postdoctoral fellow on sensory control for unmanned aerial vehicles. My postdoctoral fellow has been supported by Sensory Control for Unmanned Aerial Vehicles (SCUAV) Agence Nationale de la Recherche (ANR) project. The main objective was to improve multi-sensor-based servoing tasks for unmanned aerial vehicles. The idea was to design robust control law that combine different sensory data directly at the control level. Especially, I have contributed to the design of a new on-line sensor self-calibration based on the sensor/robot interaction links [CICL2]

[1]LAAS: `http://www.laas.fr`
[2]French National Center for Scientific Research, `http://www.cnrs.fr`

I.1.2 Tenured as Associate Professor

In 2008, I was recruited as Associate Professor of the 61st CNU section at École Nationale Supérieur d'Ingénieurs (ENSI) Bourges, which is now the Institut National des Sciences Appliquée (INSA) Centre Val de Loire[3]. Figure I.1 shows the relevant events related with my activities. Since then, I have been regularly involved in the life of the institute. In particular, I contribute at a local level to the scientific animations (eg., organization of laboratory visits), transfer and training-research links. Thus, I regularly attend the international relations division by accompanying the different delegations of schools and universities partners during their visits to INSA Centre Val de Loire. In March 2017, the direction of the INSA Centre Val de Loire given to me the mission of referent "*racism and antisemitism*".

As senior lecturer, I am mainly involved in the development of electronics and electrical sciences teaching activities of the institute. In particular, I have contributed to develop all of the teaching materials for the electronics and electrical sciences courses and tutorials. Since September 2014, I am in charge of the Nuclear Energy options of the 5th year (engineer's degree) of the Industrial Risk Control (MRI[4]) department.

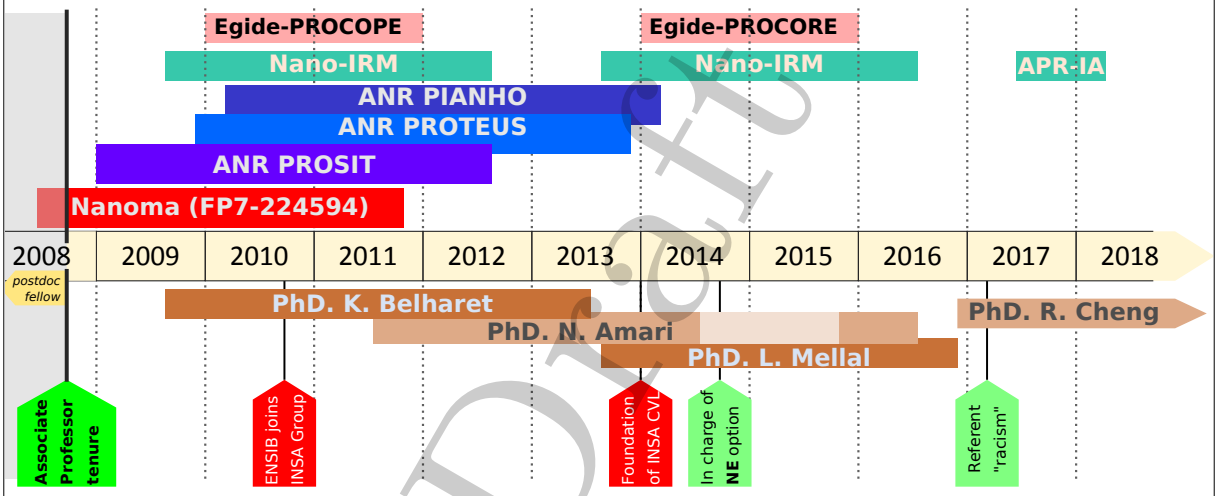


Figure I.1 – Progress of main events and activities (*e.g.* projects and supervisions) related since my tenure.

Furthermore, I perform my research activities with the PRISME[5] Laboratory in the Robotics axis of the IRAuS pole. My research interests mainly deal with modeling and control for nano and micro-robotics in a biomedical context. In a first time, my research activities have been mainly related with the European project NANOMA[6]. This project consisted to design microrobotic system for targeted drug delivery through the cardiovascular system. Parallelly, I have also contributed to the development of micromanipulation activities of the laboratory. Firstly, the micromanipulation has been devoted for intra-cytoplasmic applications [CICL4, ACL4]. Next, this research activities evolved to object micromanipulation to be placed in the focus of a light beam within the ANR[7] project PIANHO[8]. The different projects in which I have been involved

[3] INSA Centre Val de Loire (INSA CVL) was created in 2014 by the merge of École Nationale d'Ingénieurs du Val de Loire (ENIVL) of Blois and ENSI of Bourges. In 2015, the École Nationale Supérieure de la Nature et du Paysage (ENSNP) of Blois is integrated to INSA Centre Val de Loire. `http://www.insa-centrevaldeloire.fr`

[4] Maîtrise des Risques Industriels (MRI)

[5] Laboratoire Pluridisciplinaire de Recherche en Ingénierie des Systèmes, Mécanique, Énergétique [...]

[6] Nano-Actuators and Nano-Sensors for Medical Applications[...]

[7] Agence Nationale de la Recherche

[8] Innovative Haptic Instrumental platform for 3D Nano-manipulation[...]

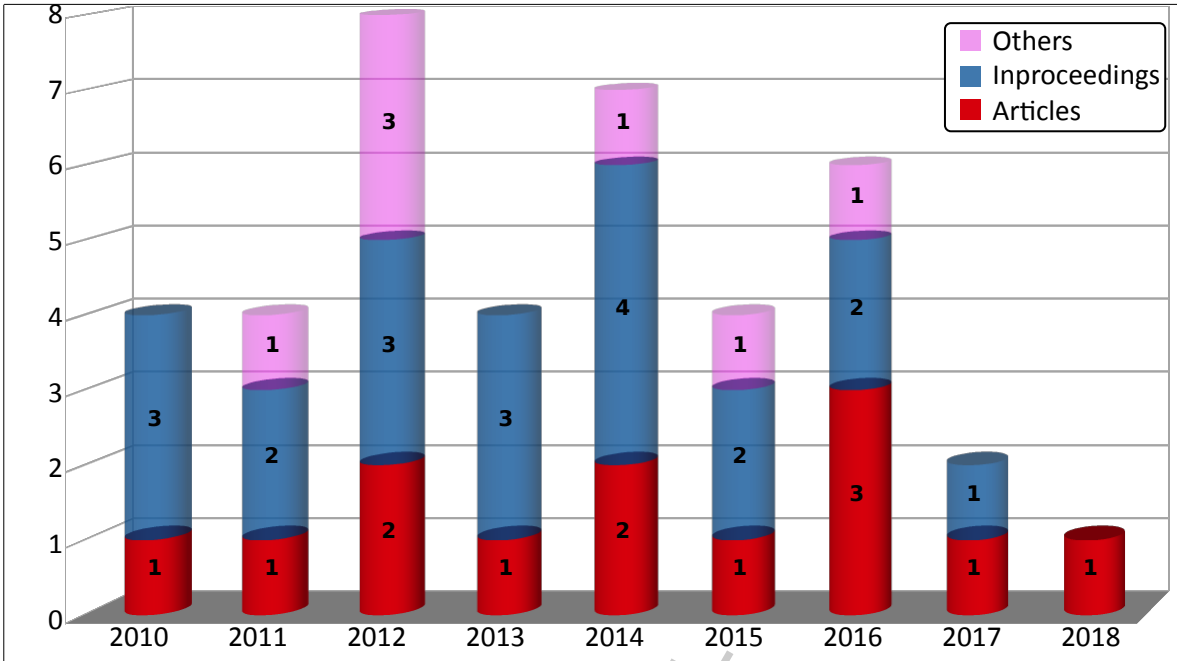


Figure I.2 – Personal references timeline evolution.

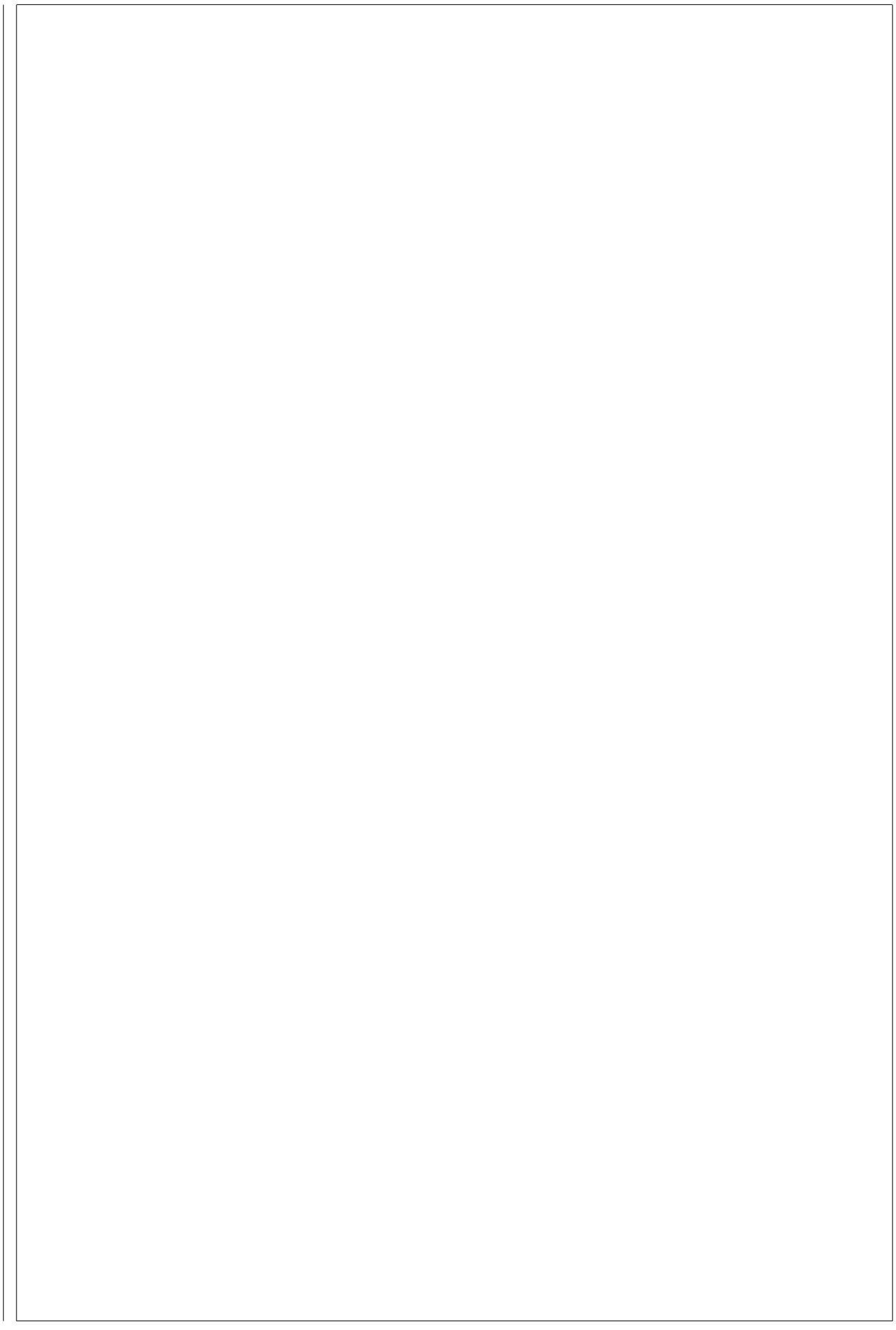
are reported in the Figure I.1, and detailed in appendix A.XX. I have co-supervised 4 PhD thesis (with one still on going) also shown in the Figure I.1, and detailed in appendix A.YY. Since 2018, I have contributed to 40 publications, including 12 articles and 20 proceedings. Figure I.2 illustrate the timeline progress of my publishing activities and the detailed list of my publications are given in appendix B.

I.2 Activities Organization

I.2.1 Teaching activities

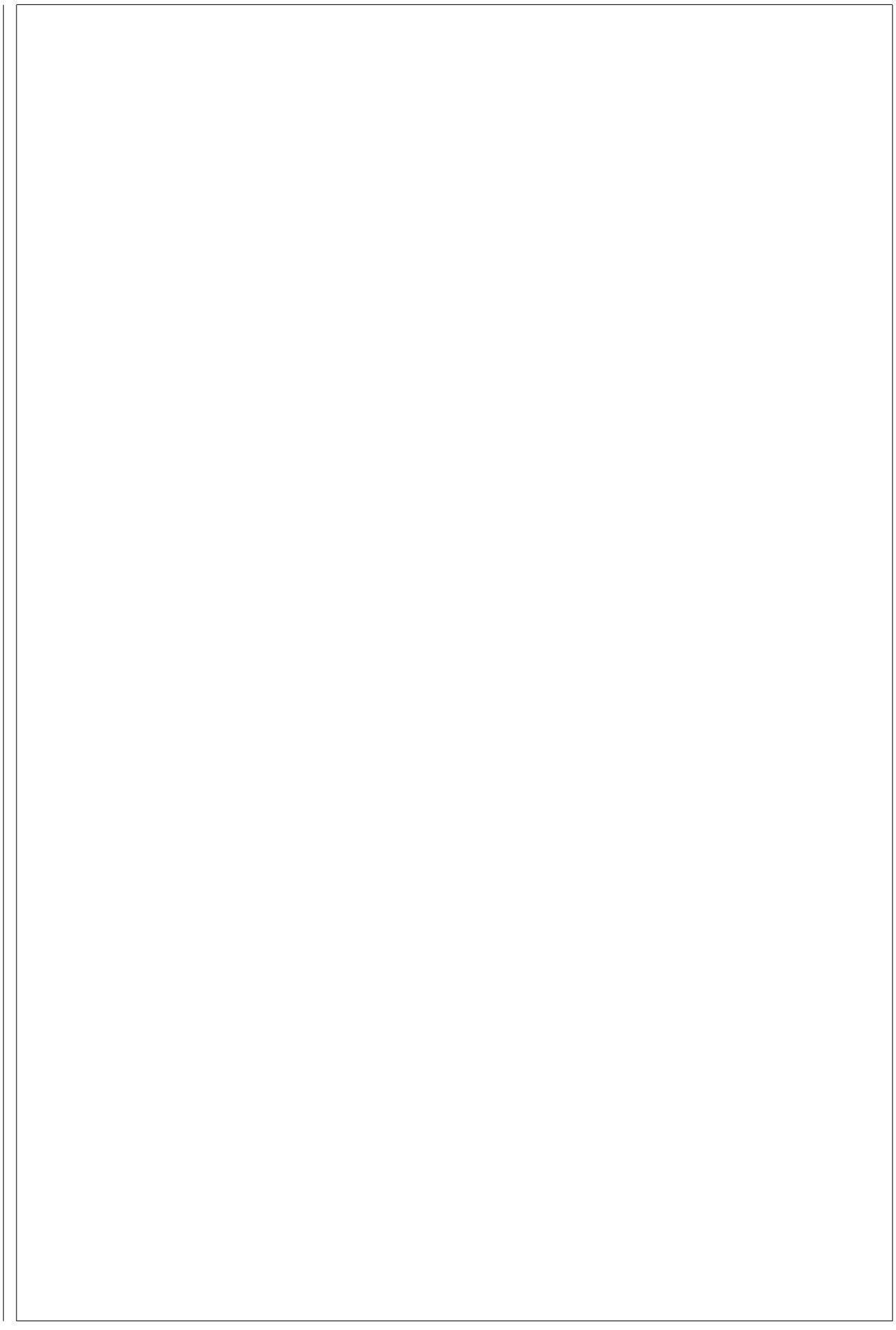
I.2.2 Research Field

I.3 Manuscript Overview



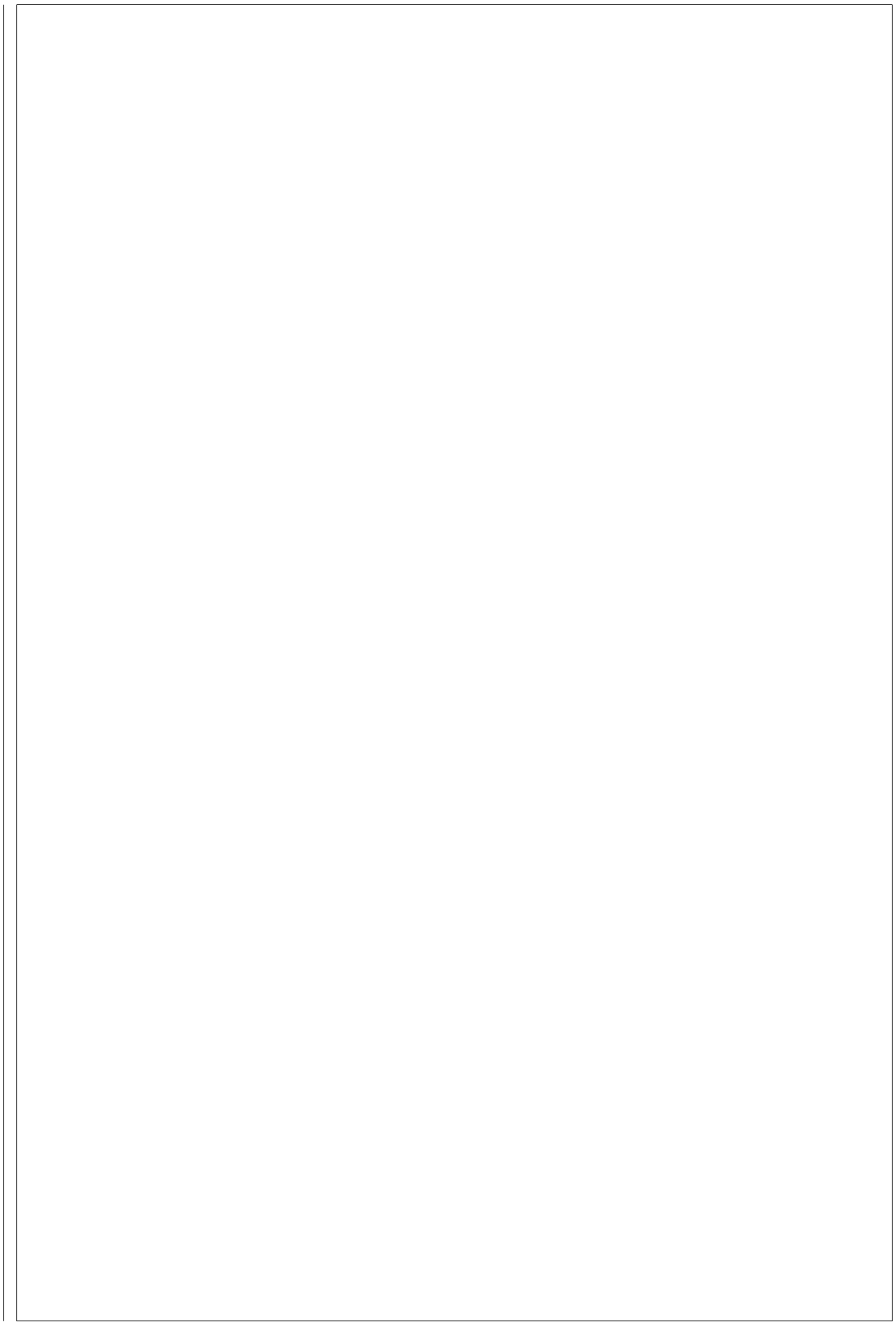
Chapter II

Chapter 2



Chapter A

Resume



Chapter B

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B.1 Articles

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[ACL12] **David Folio** and Antoine Ferreira. 2d robust magnetic resonance navigation of a ferromagnetic microrobot using pareto optimality. *IEEE Transactions on Robotics*, 33(3): 583–593, 2017. ISSN 1552-3098. doi:10.1109/TRO.2016.2638446.

B.2 Book Chapter

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[CICL9] Nabil Amari, **David Folio**, and Antoine Ferreira. Robust laser beam tracking control using micro/nano dual-stage manipulators. In *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS'2013)*, pages 1543–1548, Tokyo Big Sight, Japan, November 2013. doi:10.1109/IROS.2013.6696554.

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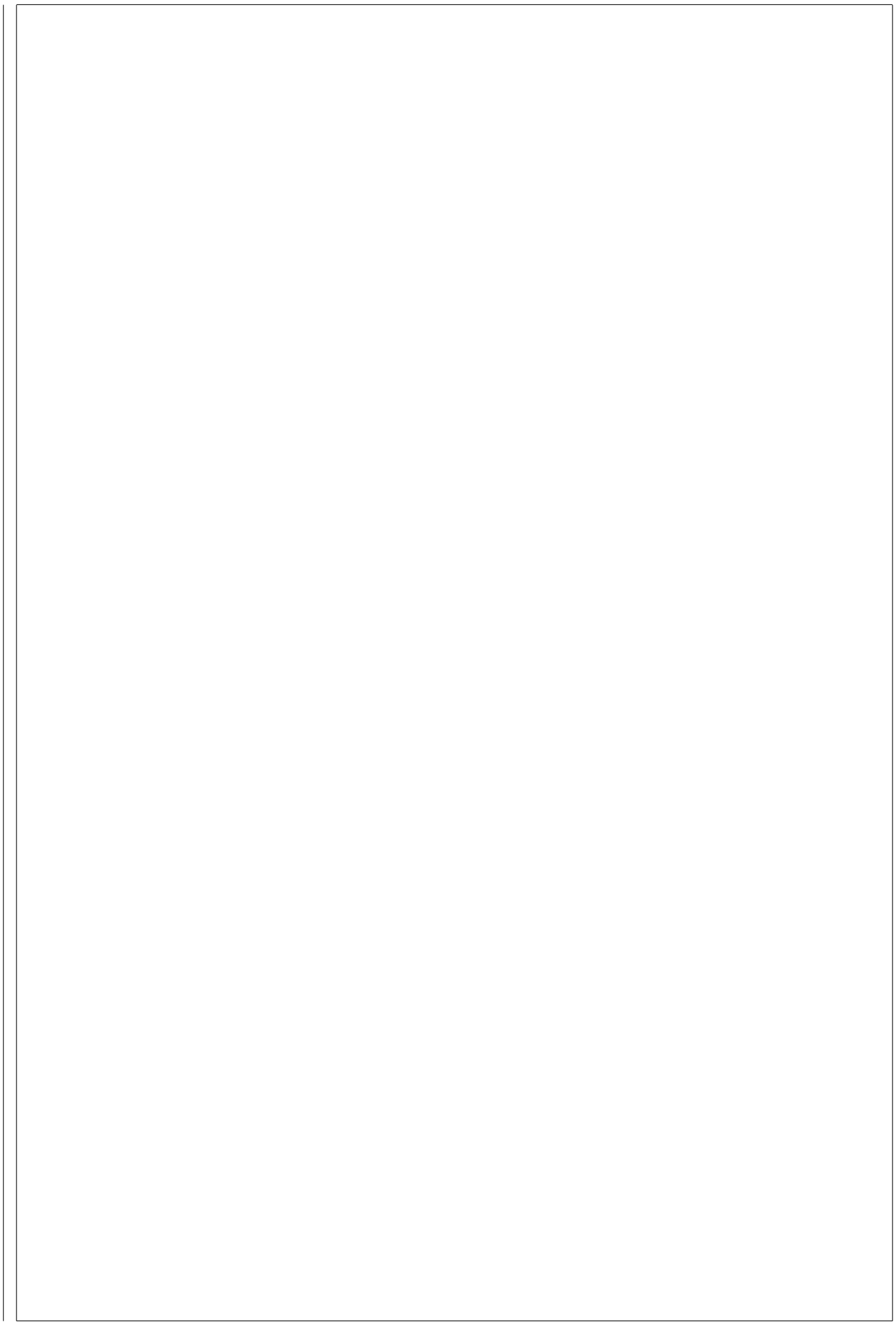

Index of terms and notations

Acronyms

ANR Agence Nationale de la Recherche

ENSI École Nationale Supérieur d'Ingénieurs

INSA Institut National des Sciences Appliquée

MRI Magnetic Resonance Imaging

NANOMA Nano-Actuators and Nano-Sensors for Medical Applications[…]

PIANHO Innovative Haptic Instrumental platform for 3D Nano-manipulation[…]

PRISME Laboratoire Pluridisciplinaire de Recherche en Ingénierie des Systèmes, Mécanique, Énergétique […]

Glossary

NANOMA project
The NANOMA project is an European project funded under FP7-ICT-2007.3.6, Micro/nanosystems, coordinated by Professor Antoine Ferreira, Université d'Orléans. The NANOMA project aims at proposing novel controlled nanorobotic delivery systems which will be designed to improve the administration of drugs in the treatment and diagnosis of breast cancer.

PIANHO project
The PIANHO project is an ANR P3N (2009) project. The objective has been to design a micromanipulation platform capable of pick, hold and place nano-objects in the synchrotron radiation beam of the ESRF, Grenoble, France.

PRISME Laboratory
The PRISME Laboratory is from Université d'Orléa,s and INSA Centre Val de Loire (EPRES 4229), `http://www.univ-orleans.fr/PRISME`. The PRISME laboratory seeks to carry out multidisciplinary research in the general domain of engineering sciences over a broad range of subject areas, including combustion in engines, energy engineering, aerodynamics, the mechanics of materials, image and signal processing, automatic control and robotics.