CONTRATS DOCTORAUX EN INTELLIGENCE ARTIFICIELLE ETABLISSEMENT

The application must follow the structure of this form. Incomplete applications and applications not using the form will not be evaluated.

Title of the PhD programme	Humans and Artificial Intelligence Sharing Control and Decisions
Contact person	Bruno Zanuttini
Institution	ComUE Normandie Université
Graduate college(-s)	Doctoral School MIIS
Requested funding	500 k€
Number of PhD theses	10
Keywords	Control; Decision; Learning; Health; Transportation

Proposal

1. General description of the program (2 pages maximum)

1.1. Summary

We propose a research program of 10 PhD theses coordinated by Normandie Université (NU), which federates the most important institutions of higher education and research in Normandy. These PhD grants will be co-funded by Région Normandie, in line with its strategy for research and innovation.

The program aims at developing novel artificial intelligence (AI) approaches in contexts where humans and AI together control systems and make decisions. An example of such contexts is autonomous vehicles, where most piloting is performed automatically, but control must be taken by the human in specific situations (e.g., reduced visibility). Another example is medical imaging-based diagnosis, where AI is used to assist physicians in the tedious task of image analysis by focusing their attention to the most meaningful images or regions of images. Yet another example is the case of a complex organization, like a harbor, in which human decisions about the management of traffic must be supported by models and prediction tools, which themselves embed expert knowledge.

Our objective is to develop ambitious and original AI techniques for such contexts and understand their fundamental underpinnings, along two main directions as suggested by the above examples:
- **sharing of control**, where AI and humans together control a system in an interactive loop (for instance, control passing back and forth between an automated and a human pilot), and
- **sharing of decisions**, where the interaction occurs essentially in two phases (for instance, AI-based segmentation of medical images, then physicians making decisions based on them).

These scientific themes are very active research areas at NU, where many teams have gained solid national and international reputation. One of the added value of this project will be to foster interaction between researchers and PhD students in both themes, around the numerous aspects common to both directions: taking into account human knowledge, modeling the human's expectations, ensuring that decisions are explainable, reliable, robust, and ethical, to cite a few.

This general objective will be instantiated on two main fields of application, for which NU has important forces: **transportation** and **health**. Normandy indeed has an important expertise on these two fields, specifically on autonomous vehicles, logistics, and medical imaging. It also enjoys important infrastructures, especially the harbor in Le Havre (2nd most important port in France, and 11th in Europe), the ARCHADE platform for hadrontherapy and the CYCERON platform for medical imaging in Caen, and the Rouen Normandy Autonomous Lab for autonomous vehicles.

These applications will drive research in various facets of AI for which NU has internationally renowned research teams and individual researchers. One can cite in particular: automated decision and planning in interaction with humans; machine learning, especially deep learning; discrete and continuous optimization; knowledge extraction and data analysis; multi-agent systems. Moreover, at the crossroads between all these techniques lie important common scientific problems, notably large-scale optimization and modeling of data, knowledge, users, and systems.

We propose to fund 10 PhD theses on these topics, with a strategy for fostering interaction between them through scientific events at different levels held on a regular basis. Our proposal does not include a definitive list of PhD subjects, since research in the targeted scientific fields and innovation in the targeted application areas evolve very fast. We will rather open a call for PhD subjects once this program is funded, have the proposals and candidates reviewed and ranked by external experts, and decide which to fund depending on these evaluations and on a balance between the scientific directions outlined above, a process successfully used for several years at NU.

1.2. Institution presentation. Research team(-s) involved in the project (CVs of potential supervisors should be uploaded as an annex file – up to one page per person)

The ComUE Normandie Université (NU) federates 6 institutions of higher education and research. Research is structured in 5 research and training clusters which are in line with the Master and PhD degrees. These clusters mirror the 5 axes of interest for Région Normandie (called “Réseaux d’Intérêt Normands”, RIN). The SN cluster (“Sciences du Numérique”, i.e., “Digital Sciences”) is the main one, but not the only one, involved in this proposal.

NU is the only institution in Normandy which awards the doctoral degree. This is handled through 8 doctoral schools which gather together PhD students of the Norman universities and graduate schools of engineers. Among them, the doctoral school MIIS (“Mathematics, Information, System Engineering”) is in charge of coordinating this PhD program.

The main laboratories involved in this program are

- GREYC in Caen (UMR 6072), with more than 90 researchers and 50 PhD students; research teams Image, CoDaG, HULTECH, and MAD have well-established expertise in data (e.g., signal/image/video) processing and machine learning, data mining, natural language processing, and automated planning and multi-agent systems;
- LITIS in Rouen and Le Havre (EA 4108), with more than 100 researchers and 50 PhD students; teams RI2C, MIND, Quantif, STI, and App have well-established expertise about complex systems, multi-agent systems and man-machine interaction, analysis and classification of medical images, intelligent transportation systems, and statistical machine learning.

There are other laboratories involved, especially in mathematics (LMI in Rouen with expertise in optimization and machine learning, LMNO in Caen and LMRS in Rouen on statistical machine learning), in engineering (IRSEEM in Rouen about autonomous cars), and in control theory (LAC in Caen about autonomous river shuttles). All the laboratories involved are part of the same cluster SN, the same doctoral school MIIS, and have a long-standing experience of working together. They also constitute two CNRS federations (Normastic – FR 3638 and Normandie Mathématiques – FR 3335).

We also plan to have several funded PhD theses which will be co-supervised by researchers in health sciences, especially from laboratories hosted by the platform for medical imaging CYCERON (Support CYCERON - UMS 3408, PhinD - UMR-S 1237, COMETE - UMR-S 1075, SEILIRM - EA 4650), from the university hospital (CHU) in Caen, and from the Henri Becquerel center against cancer (CHB) in Rouen. As for transportation, the laboratories of the SN cluster are already directly involved in the applications, notably through their implication in the Rouen Normandy Autonomous Lab and in clusters in logistics. Yet, there will also be important collaborations with structures such as the ISEL graduate school of engineers which is specialized in logistics, and with the other teams of SFLog, an interdisciplinary research structure dedicated to logistics in Normandy. In general, co-supervisions with teams from other fields (than mathematics and computer science) will be encouraged.

1.3. Graduate college(-s) presentation

The doctoral school “Mathematics, Information, System Engineering” (MIIS) is one of the 8 doctoral schools of Normandie University, gathering together PhD students from the 3 universities and the INSA graduate school of engineers. It manages PhDs in computer science, control theory, applied and pure mathematics, mechanics, and electronics, and involves the same laboratories as the SN cluster. MIIS comprises more than 150 PhD students, among which about 100 come from abroad, 15 are co-supervised with another country, and 25 are hosted in a company (“convention CIFRE”). As the unique doctoral school with computer science and mathematics in its perimeter, MIIS gathers all PhD theses of NU which are directly related to AI, which makes it the natural leader for this program.

2. Scientific, technical and strategic description

2.1. AI research strategy

This proposal, **"Humans and Artificial Intelligence Sharing Control and Decisions" (HAISCoDe)**, aims at developing artificial intelligence (AI) techniques in contexts where humans and artificial intelligence together control systems and make decisions. For this, we propose to fund 10 PhD theses, with subjects selected among the answers to a call at the Normandy level, on topics related to two scientific directions: **sharing of control**, involving in particular automated planning, multi-agent systems, and man-machine interaction, with applications to autonomous vehicles and logistics, and **sharing of decisions**, involving in particular machine learning, knowledge extraction, and data analysis, and with important applications to health.

The rationale behind this proposal is threefold:

- the laboratories involved in this project have an important recognized expertise in the above-mentioned subfields of AI as well as in the application domains;
- the two axes are complementary to each other: when control is shared, interaction is continual between AI and the human(s) (like control passing back and forth between AI and the pilot controlling an aircraft), while for sharing of decisions, the process typically involves two phases (like AI-based segmentation of medical images, then physicians making decisions based on this);
- the two axes involve important common research questions, like modeling of the human, explainability of decisions, reliability, robustness, etc., so that this PhD program will pave the way to the emergence of new projects involving expertise from the two axes.

We now give a detailed description of the program HAISCoDe along these two axes, then along their interactions. For clarity, the main actors are located on a map of Normandy in Figure 1. Curriculum Vitæ of potential PhD supervisors are given in the appendix.

Sharing of control By "humans and AI sharing control", we mean scenarios in which AI typically controls a system, but human assistance is required in various situations, so that control passes back and forth between AI and the human(s). Such scenarios are unavoidable with autonomous vehicles: human control is needed in hard driving conditions, when sensors are faulty or not enough to assess the situation, etc. They also occur in the control of complex systems, such as the traffic in a harbor: though some procedures can be automated, others still require human intervention, as in the case of conflicts, unforeseen situations, etc.

There are numerous scientific questions arising specifically from such scenarios, in particular:

- how to decide when control should be given to the human, and taken back by the AI,
- when the system is controlled by the AI, how to ensure that the humans stay aware enough of the current situation so as to be able to take control whenever needed,
- how to model the system to be controlled so that the AI and humans reason about it using a common and understandable model,
- how to model and predict human behavior, in order to predict when control should change hand,
- how to interact with the human,
- how to ensure safety and reliability of such shared control,
- etc.

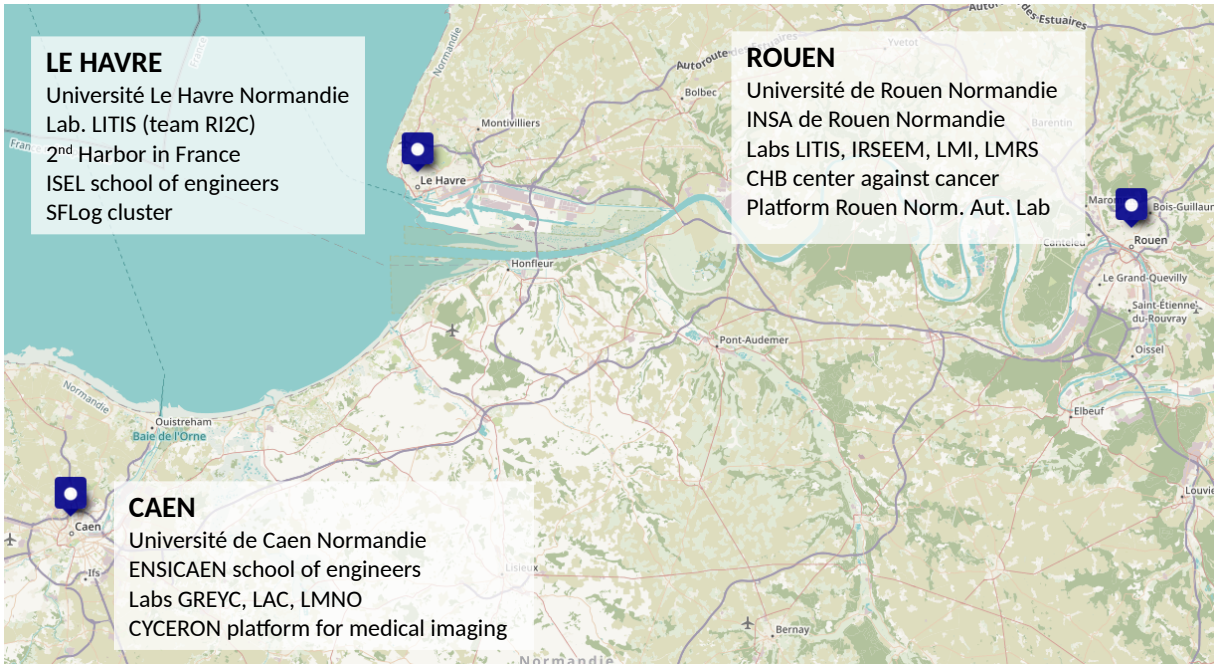

Figure 1. Location of the main actors of HAISCoDe.

This topic is particularly well supported by the research teams involved in HAISCoDe.

The GREYC has expertise in automated planning, especially in multi-agent systems involving humans and adjustable autonomy, and in reliability and trustability of autonomous systems, notably through its team MAD. Abdel-Illah Mouaddib has recently coordinated the EU-funded collaborative project COACHES, on decision-making for groups of robots in public spaces,[1] a project which is now continued into an innovation project supervised by TTO Normandie Valorisation. He also coordinated GARDES, a project funded by ANR, DGA, and Nexter Robotics about adjustable autonomy.[2] Grégory Bonnet has recently coordinated the ANR-funded collaborative project ETHICAA on agents reasoning about ethical issues so as to be able to explain their decisions.[3]

LITIS has expertise first in interaction in systems involving agents and humans as well as collaborative distributed decision making. Alexandre Pauchet (MIND team) has been the coordinator of the ANR-funded project NARECA, whose topic was the design of a narrative embodied conversational agent.[4] LITIS also has expertise in modeling complex systems; its team RI2C manages the ISCN ("Norman Institute for Complex Systems"), a member of the UniTwin Unesco Complex Systems Digital Campus,[5] and many regional projects oriented towards port logistics. It also considers the monitoring of such systems for preventing risks; Andrea Santos leads project OLIC ("Optimization of Logistics for Large Scale Disasters").[6] Furthermore, it has acquired expertise in managing collective robotics (swarms of drones) through for instance the Drivelog project, co-led by Frédéric Guinand and involving industrial partners, including Compagny Bolloré. Finally, LITIS has well-established expertise on the use of

1 http://www.chistera.eu/projects/coaches
2 https://anr.fr/Project-ANR-14-ASTR-0018
3 https://anr.fr/Project-ANR-13-CORD-0006
4 https://anr.fr/Project-ANR-13-CORD-0015
5 http://www.cs-dc.org/
6 http://losi.utt.fr/fr/olic.html

information sciences and technologies for one of the application domains of this project, namely advanced driving assistance systems (ADAS), through its team STI. Samia Ainouz coordinates the ANR-funded project ICUB,[7] which aims at designing and developing a new vision based system able to detect road obstacles, even in critical situations, in collaboration in particular with two industrial partners (STEREOLABS and PSA).

Laboratory IRSEEM also has a specific expertise on autonomous vehicles. Its expertise about this application is more specifically on the instrumental and experimental sides (robotics, sensors, datasets…), including more fundamental issues such as fusion of multimodal sensors, automatic labeling of datasets, etc. The IRSEEM is involved in the Rouen Normandy Autonomous Lab platform[8] (see below) and also has its own platform (vehicle equipped with sensors, in particular).

Finally, the LAC is a laboratory specialized in process control and observation. The LAC is involved in the NEAC project ("Autonomous Electric Shuttle on the Canal")[9] dedicated to the development of an autonomous electric river shuttle allowing the transport of 8 to 10 people from one bank to the other of the Caen Canal. This project is part of a larger one involving in particular Normandy Harbors and the city of Caen, and the LAC is in charge of trajectory control issues.

Summarizing, the teams involved in this project have a strong expertise on the problems of decision making, interacting with the human, learning, and system modeling as specific to sharing of control, in particular for autonomous vehicles. There are an important expertise and important infrastructures dedicated to autonomous vehicles; in particular, the Rouen Normandy Autonomous Lab platform is the first service of on-demand mobility with autonomous vehicles open to public in Europe, and it has been selected for the national program EVRA ("Experimentation of Autonomous Road Vehicle"). Logistics is also an important application domain in Normandy, especially due to Le Havre Harbor being one of the most important commercial harbors in Europe. Researchers of a great variety of disciplines are gathered in a federation dedicated to logistics ("Federative Structure for Research in Logistics", SFLog), and more generally, Normandy hosts the Nov@log competitiveness cluster, which federates higher education institutions, companies, and administrations around logistics.

For these reasons, this PhD program involves a first axis around these themes. Even if proposals are not definitive and will be selected in due time, here is a preliminary list of subjects to be proposed:

- adjustable autonomy in sequential decision-making problems (GREYC),
- automating, securing, and increasing the speed of transit of goods in harbors (LITIS),
- information fusion of multimodal sensors for autonomous vehicles (IRSEEM),
- towards artificial agents in symbiotic interaction with humans (LITIS),
- from perception to decision-making for intelligent mobility (LITIS),
- decentralized control of drone swarms (LITIS),
- safety issues in applying AI to mobility (LITIS).

Projects may also be proposed which appeal to the same fundamental problems and AI techniques related to control sharing between AI and humans, though apart from the transportation application field, in particular:

- real time monitoring of a biological environment (LITIS and SEBIO – UMR-I 02, specialized in environmental questions).

7 https://anr.fr/Project-ANR-17-CE22-0011
8 https://www.rouennormandyautonomouslab.com/?lang=en
9 https://www.portdufutur.fr/innovations-portuaires/projets-innovants/neac-industry

Sharing of decisions By “humans and AI sharing decisions”, we mean scenarios in which AI supports decisions which will eventually be made by humans, typically using data analysis/modeling/processing and machine learning for prediction. Such scenarios are in particular at the heart of medical diagnosis as supported by AI, as typically encountered in medical imaging-based diagnosis, where the goal is to assist physicians in their quest to detect and track abnormalities without visually analyzing hundreds of images. They also occur in data analysis, again applied to health such as in the search for new drugs through computer-aided analysis of millions of molecules in chemoinformatics, or applied to other domains as in the computer-aided analysis of huge amounts of data, where AI helps researchers to find regularities or outliers, depending on the application.

Again, there are numerous scientific questions arising specifically from such scenarios, in particular:

- how to tailor machine learning techniques to the automatic analysis and classification of specific data (MR images, echographic images, cardiovascular images, but also speeches and texts for diseases such as depression), for maximizing the prediction quality,
- how to extract knowledge (regularities, outliers, etc.) from structured data, like graphs (molecules) or sequences (proteomic sequences),
- how to exploit machine learning techniques for the classification of such data,
- how to ensure and quantify explainability, reliability, and robustness of such predictions and extracted knowledge so as to yield reliable decision making,
- how to model the user’s preferences about the information to be extracted from the data, and how to elicit these preferences,
- etc.

Like for the first axis, there is strong expertise about these topics among the research teams involved in HAISCoDe. Through its team Image, GREYC has renowned expertise in machine learning and data processing and analysis, and their applications to vision and image analysis, notably in the medical domain. For instance, it is involved in the EU-funded project NoMADS about nonlocal methods for data processing and analysis, with a particular focus on biological and medical images.[10] It is also particularly involved in technology transfer in this domain; DATEXIM[11] is a company created in 2011 as a spin-off, which develops innovative software for analysis of medical images. GREYC also performs research in decision making based on data, from understanding the data up to and including how to make the decision itself. Its team CoDaG co-coordinated the CNRS Mastodons DECADE project, about exploiting knowledge derived both from data and from domain experts, in the case of pharmaceutical chemistry.[12] More generally, the CoDaG team has carried out significant projects dedicated to chemoinformatics, data processing for drug design, in collaboration with the CERMN, a laboratory in chemistry in Caen with a particular focus on drug design and evaluation. Finally, the GREYC performs research on speech and text analysis, through its team HULTECH; in this context, it performs research on the automatic estimation of depression levels based on multimodal characteristics: video, acoustics, and text. The models developed by the team, which are based on recurrent neural networks, are the current state of the art for this specific task on the DAIC-WOZ gold standard dataset.[13]

In LITIS, the Quantif team performs research in particular about the optimization and analysis of medical images, and the use of segmentation, fusion, and classification methods for medical images. It is tightly tied with the medical application domain, and comprises researchers in computer science as well as researchers in health sciences with an activity in a hospital (“professeurs des universités

10 https://cordis.europa.eu/project/rcn/212978/factsheet/fr
11 https://www.datexim.com/en/
12 https://zimmermanna.users.greyc.fr/projects/decade.html
13 http://dcapswoz.ict.usc.edu/

praticiens hospitaliers"). Members of the team co-lead one of the 5 research axes of "Cancéropôle Nord-Ouest", a cluster dedicated to cancer and covering the North-West of France.[14]

There is also a strong expertise on the application domain of health, especially with teams hosted by the CYCERON platform. PhD theses within this domain of application will be co-supervised by a member of one of the teams in the fields of computer science or applied mathematics, and by a member of a team in the medical field. Among these, members from CYCERON (UMS 3408 -UNICAEN-CNRS) will bring their expertise on medical image acquisition, analysis, and an access to MRI and echocardiography images. Members from COMETE (UMR-S 1075 UNICAEN - INSERM) will bring their abilities to physiological signal acquisition and integration in mathematical models in order to evaluate various behavioral states (sleepiness, alertness...). Members from PhinD (UMR-S 1237 INSERM) are specialists of clinical and pre-clinical stroke and can provide their expertise on MRI images, biological mechanisms and diagnosis. Cardiologists from SEILIRM (EA 4650 UNICAEN) will bring their skills in acquisition and diagnosis of medical heart images as they have already done during collaboration with Philips healthcare (MRA).

In summary, the teams involved in this project have a strong expertise in statistical machine learning, such as deep learning, knowledge extraction, data processing and analysis, as well as classification for images and natural language, complemented by a history of collaborative work with teams in the medical and chemoinformatic field. There are also important infrastructures supporting this axis, in particular the shared computing center CRIANN for massive computations required by machine learning,[15] the ARCHADE center dedicated to the treatment of cancer,[16] and the CYCERON platform for medical imaging.[17]

Hence this PhD programme involves a second axis around these themes. Again, proposals are not definitive and will be selected in due time, but here is a preliminary list of subjects:

- analysis of post-stroke MR images (GREYC and PhinD),
- automated quantification of echocardiographic tests (GREYC, SEILIRM, and UMS Support CYCERON),
- automated detection of normality or abnormality of a focused echocardiography, based on in-depth learning of a labelled database (SEILIRM, UMS Support CYCERON, Caen University Hospital and GREYC),
- automated detection of altertness during a functional cerebral MRI acquisition (COMETE INSERM and UMS Support CYCERON),
- geometric models and learning for the analysis of medical images (LMI),
- automatic depression level estimation (GREYC),
- automatic report generation from medical images (GREYC),
- semi-supervised deep learning and a priori models applied to medical images for radiotherapy (LITIS and CHB).

Projects may also be proposed which appeal to the same fundamental problems and AI techniques, related to sharing decisions between AI and humans, though apart from the medical application field, in particular:

- analysis of simulation data in fluid mechanics (LITIS and CORIA - UMR 6614, specialized in combustion),

14 https://www.canceropole-nordouest.org/
15 https://www.criann.fr/
16 http://archade.fr/
17 http://www.cyceron.fr/

- analysis of time-resolved spectroscopic images (GREYC and LCS - UMR 6506, with expertise in particular in spectroscopy in catalysis).

Interactions between the two axes The two main axes of this proposal raise important, common scientific questions. These pertain to modeling of human preferences (what information the human expects from the system), elicitation of these, modeling of complex and dynamic systems, machine learning, optimization (especially in large scale), and explainability and reliability of analyses and decisions made by the AI.

By having 10 PhD theses ongoing during the same period on these hot topics, we want to create a synergy between the involved students and researchers so that specific expertise on these fields lying at the crossroads of the two axes be transferred, and that new collaborations emerge, fostered by the students' work. For this, we plan to organize, twice per year, a scientific meeting gathering together all PhD students and supervisors funded by this program, during which all students will present their ongoing work and scientific challenges related to their PhD. This should allow each involved participant to acquire a general knowledge of the main problems and techniques related to control and decision sharing between humans and AI, and foster the emergence of new research projects, especially across the two axes.

For instance, one can expect work in classification of medical images to benefit from techniques about user modeling, as typically put forward in adjustable autonomy, to design more integrated approaches in which the expectations of physicians about decision support can be modelled and taken into account in the classification phase. Dually, one can expect advances in machine learning and prediction techniques to be useful to work in the first axis, for instance for the classification of situations where control should be given to the human *vs* to the AI.

Of course, these meetings will be open to all researchers in the involved research teams. Later meetings, when PhD are in their third year, will also be open to a public audience (see Section 3.3).

2.2. Description of the supervision team

The PhD theses funded by this program will be supervised by researchers of the teams described in Section 2.1. Each PhD will be supervised by a member of a team in the fields of Computer Science or Applied Maths, and possibly co-supervised by a member of a team in another field (health sciences, logistics, humanities, control theory, etc.). All PhDs will take place within the doctoral school MIIS.

As described at the end of the latter section, **a meeting will be organized twice per year, bringing together all involved PhD students and supervisors**. This will contribute to create a synergy between all theses in this program.

The whole program will be supervised by the **doctoral school MIIS** (see Section 1.3), whose head, Bruno Zanuttini, is the coordinator of this project. The doctoral school will supervise the project and be responsible for monitoring the progress of the PhD theses with the help of follow-up committees. Whenever applicable, doctoral schools of cosupervisors will be involved as well in such supervision.

The project will also be supervised by the **steering committee of the SN cluster**. This cluster federates all the research labs of Normandy in digital sciences (see Section 1.2), from fundamental research to development of technologies: computer science, pure and applied mathematics, signal and image processing, control theory, some aspects of electronics... One of the roles of the SN cluster is indeed the structuring and animation of research in its field of expertise. Given its strategic role in Normandy, this cluster has now a well-established experience in organizing PhD grant calls (6-9 grants

per year since 2017) and the corresponding selection process. Our project here will clearly capitalize on this experience. Moreover, the diversity of themes in this cluster, apart from AI, will ensure that the program will be followed also with a point of view external to the field. Colleagues from the steering committee of the CBSB cluster, which federates research in health sciences (among others) and from the steering committee of the CTM cluster, which federates research in the land/sea continuum (and notably for us harbor logistics), will be associated to such supervision, as well as colleagues from the steering committee of the other Norman clusters if some of the selected PhDs are co-supervised in their domain.

Concretely, the doctoral school will ensure the monitoring of each PhD thesis, starting from the organization of the selection process of the subjects and the hearing and selection of candidates, and continuing with follow-up committees, validation of the defense jury, etc. Animation, and precisely the organization of the scientific events as well as the expertise of subjects, will be supervised by the steering committee of the SN cluster (and possibly other Norman clusters). It is important to note that the doctoral school has a representative in the steering committee of the SN cluster, and that the CNRS federations NormaSTIC and Normandie Mathématiques each also have one. Moreover, we recall that the SN cluster and the doctoral school MIIS gather together the same research laboratories, so that supervision of the program will easily be done in a smooth and consistent manner.

2.3. Accompanying measures (computational resources, platforms…)

As detailed in Section 2.1, the PhD students will have access to the **high-performance computational resources** provided by the CRIANN HPC infrastructure, as well as to the usual resources available in the research laboratories (offices, computers, etc.); individual computers will be funded by the program. In addition to this, the PhD students will have access to the **preexisting platforms in Normandy**: Rouen Normandie Autonomous Lab, the CYCERON platform for medical imaging, the ARCHADE platform for hadrontherapy, etc.

The extra funding (with respect to salaries) will allow the PhD students and supervisors to invite researchers from other institutions for seminars or short stays, and the PhD students to attend summer schools and conferences. It will also allow them to visit other labs for short or longer stays, which will be strongly encouraged by the supervision team. Note that the doctoral school MIIS already encourages this for all students, by providing funding for such stays.

Finally, all PhD students will benefit from the environment of Normandie Université and the doctoral school MIIS. Normandie Université proposes a broad **training program** for the students of all doctoral schools, dedicated to soft skills. MIIS offers a training program with discipline-specific courses, among which a number of research-oriented courses which are available in the Master programs of Normandie. As part of the training program, it also offers financial support to students who attend summer schools, a possibility which is widely used by PhD students. A specific attention is also paid by MIIS to **follow-up committees**: each PhD student has a committee comprising at least one member external to Normandie Université, and the committee must meet at least once per year, starting from the end of the first year. This ensures that the advances, but also the conditions of the PhD, including supervision, are monitored by the board of the doctoral school from the start, for the unique benefit of the student.

3. Impact

3.1. Contribution to the National AI Research Programme

The two main application fields of this program are **transportation** (autonomous vehicles – cars and river shuttles – and logistics, especially for harbors) and **health** (decision support in medical imaging through machine learning and knowledge extraction). These are two directions out of four in the National AI Research Program.

Despite the fact that HAISCoDe primarily targets the development of AI techniques, it is supported by concrete, preexisting platforms and by co-supervisions. Hence the research work performed during this program will be directly beneficial to the application domains, notably through the platforms in which the researchers involved in this project are concretely active (e.g., the laboratories hosted by CYCERON for health sciences, the ISEL school and the SFLog federation for logistics, and the researchers in LITIS and IRSEEM directly involved in the Rouen Normandy Autonomous Lab for autonomous vehicles). In particular, the platforms will enable real-world experimentations and tests on real-world data for the PhDs.

Apart from these two main application domains (transportation and health), a small part of the PhD program may also address questions related to defence and security, especially with adjustable autonomy (axis “sharing of control”), which has already been explored by the MAD team in GREYC for such applications within an ANR-DGA funded project, and questions related to environment, through modelling and control of complex environmental systems in the project with laboratory SEBIO (see Section 2.1, axis “sharing of control”), and to energy/environment, through the analysis of data in the two projects with laboratories LCS and CORIA (see Section 2.1, axis “sharing of decisions”). Les us however emphasize that, contrary to autonomous vehicles, logistics, and health, the PhD program will not focus on these application domains.

3.2. Contribution to the AI research strategy of the institution and its potential partners

The program HAISCoDe is in line with the recent, important structuration of research in Normandy, through the creation of the **SN cluster** (2017) and the **CNRS federations**, especially NormaSTIC in computer science (created in 2014). Indeed, the SN cluster has two axes out of five which are directly consistent with this program: “data science”, which gathers research work based on data, especially machine learning and data mining, directly in line with the second axis of the present proposal, and “connected systems, services and objects”, which gathers research work related to control and system modeling, in line with the first axis. Hence HAISCoDe will contribute to this structuring of research at the whole scale of Normandy.

This program is also in line with three proposals of **AI chairs** which have been submitted to the ANR in July, 2019: one involving research about trustable and explainable deep learning (Frédéric Jurie, GREYC), one involving research about safe AI in mobility (Stéphane Canu, LITIS), and one involving research about planning, learning, and decision (Abdel-Illah Mouaddib, GREYC). These chair proposals have a significant part in common with the themes and domains of the present program. Hence this program will have a transforming effect by allowing Normandie Université to consolidate its research in AI along the strategic directions presented above.

Importantly, HAISCoDe will also strengthen the dynamic fostered by **Région Normandie**. Normandy indeed has an ambitious strategy of significantly increasing the number of PhD graduates on its territory, and has been supporting this for several years now by funding a significant number of PhD theses, with a strong incentive to have PhDs co-funded with another partner. Hence the program

HAISCoDe is in a strong agreement with this strategy, and Région Normandie has committed to provide co-funding for all the PhD grants we ask for in this program.

Now from a thematic point of view, Région Normandie has put forward in its specialization strategy **"Innovation in biomedical sciences and technologies"** and **"Multimodality and efficiency in logistics"**. The application domains of this program will clearly contribute to this strategy.

As examples of the support of Région Normandie to PhDs on the themes of HAISCoDe, it has funded 8 PhD grants and co-funded 4 in 2018 for the SN cluster (and doctoral school MIIS), among which 4 and 3, respectively, were on these themes; for instance, "Human activity classification and automatic analysis of the autonomy of persons with mental diseases using deep learning" and "interactive framework for pattern discovery taking into account the user's preferences". In 2019, the figures were exactly the same, with PhD subjects such as "mixed-initiative decision for control and coordination of semi-autonomous robots interacting with operators" and "numerical optimal transportation and learning: theory and application to segmentation of medical images".

Finally, and most importantly, the program HAISCoDe will **foster interaction between laboratories with specific expertise in the different places of Normandy**, by pushing forward scientific directions which involve synergies, in particular:

- through the first axis ("sharing of control"), interaction will be fostered on the one hand between laboratories in Caen (GREYC, LAC) and in Rouen (LITIS, IRSEEM) around the application to autonomous vehicles, which currently involves research essentially in Rouen, around the Rouen Normandy Autonomous Lab, and between laboratories in Caen (GREYC) and Le Havre (LITIS) around the application to logistics;
- through the second axis ("sharing of decisions"), interaction will be fostered between laboratories in Caen (GREYC and the laboratories hosted by CYCERON) and in Rouen (LITIS) around the issues related to AI-supported medical imaging and diagnosis.

Such interaction will be made possible by the scientific events which will be organized during the program, as described at the end of Section 2.1. It will enable Normandy to start leveraging research expertise from specific places to the whole research community of Normandie Université concerned with AI. This will give **more visibility to the excellence of this community** on the specific fields of AI involved in this project, both fundamental (planning, man-machine interaction, modelling of complex systems, machine learning, large-scale optimization…) and applicative (autonomous vehicles, logistics, medical imaging…), and will help researchers **apply for projects at a larger scale**, especially EU-funded.

3.3. Proposed measures for the dissemination and exploitation of results, particularly in terms of interdisciplinarity, as part of the integration into the IA network

Recall from the end of Section 2.1 that we will organize a scientific meeting gathering together all funded PhD students and their supervisors, twice per year.

When PhDs are in their last year, the **final meeting** which will be organized, gathering together all PhD students funded by this program and their supervisors for presentation of the work, will be **largely advertised in the scientific community** (via mailing-lists, via associations like AFIA, through a dedicated website, etc.). The unified axes of this proposal will foster readability of the program of this meeting. A part of the funding will be dedicated for inviting researchers to attend, like is typically done in a workshop at the end of a funded project. This will give the opportunity to the funded PhD students to meet other researchers and present their work, and also to get external feedback on this

work, in addition to the feedback received in earlier meetings (see below).

During the last year of the program as well, **a meeting will be organized targeting a public audience**, again based on the PhD students' work. This meeting will be organized with Région Normandie, which strongly encourages such events, and the support of local associations for the promotion of science (Le Dôme in Caen[18] and Science Action in Rouen[19]). It will allow a large audience to get a grasp of recent advances in AI, and will give the PhD students an experience of a nonprofessional audience.

During the other biannual meetings, colleagues from other institutions will also be invited for giving feedback to the PhD students and to the program in general. Colleagues will be primarily solicited through the "Instituts 3IA" as part of their animation role, especially 3IA Côte d'Azur in Nice as concerns machine learning and health, ANITI in Toulouse as concerns autonomous systems, and PRAIRIE in Paris as concerns health and transportation.

Mobility and visits to other laboratories will be funded and strongly encouraged for the funded PhD students, as explained in Section 2.3. This will also contribute to the dissemination of results.

Finally, all publications will be pushed to the **open archive server HAL** of CNRS, hence contributing to open science. With the help of the local associations cited above, PhD students will also be asked to participate at least one per year to an action for the **promotion and dissemination of science towards the public** ("Fête de la Science", "Pint of Science", presentations in primary or secondary schools, etc.). Note that publication on open archives and dissemination of science are already asked to all PhD students in the doctoral school, with a particular attention paid by Région Normandie to dissemination for the PhDs funded by its grants.

4. Quality and efficiency of the implementation

4.1. Selection/recruitment process (transparency, composition and organisation of selection committees, evaluation criteria, equal opportunities, gender equality)

The process which we propose is based on the one used successfully during the last three years for selecting PhD theses and candidates for funding or co-funding provided by Région Normandie. This process is performed by the SN cluster and the doctoral school MIIS together. The whole process is summarized on Figure 2.

Once the program HAISCoDe is accepted, the supervision team will send a call for PhD subject proposals, on the themes and application domains described in Section 2.1, to the research labs in Normandie Université, through the 5 scientific clusters and the 8 doctoral schools. Subjects will be proposed with a candidate, if one is already known, otherwise without a candidate. In parallel to this call, a pool of reviewers external to Normandie Université will be constituted by the steering committee of the SN cluster.

The received proposals will first be analyzed by the **committee of the SN cluster together with a representative of each of the 4 other clusters (hereafter "the board")**, and proposals which are out of scope will be rejected. With excellence as an ultimate goal, each other proposal will be sent out to **two external reviewers** (recognized experts in the corresponding field), who will be asked to give a detailed assessment of the scientific quality of the subject, the supervisor, and the candidate, if applicable.[20]

18 http://ledome.info/
19 https://www.scienceaction.asso.fr/
20 To ensure efficiency, each expert will be paid a honorarium as is done currently in all clusters of Normandie Université.

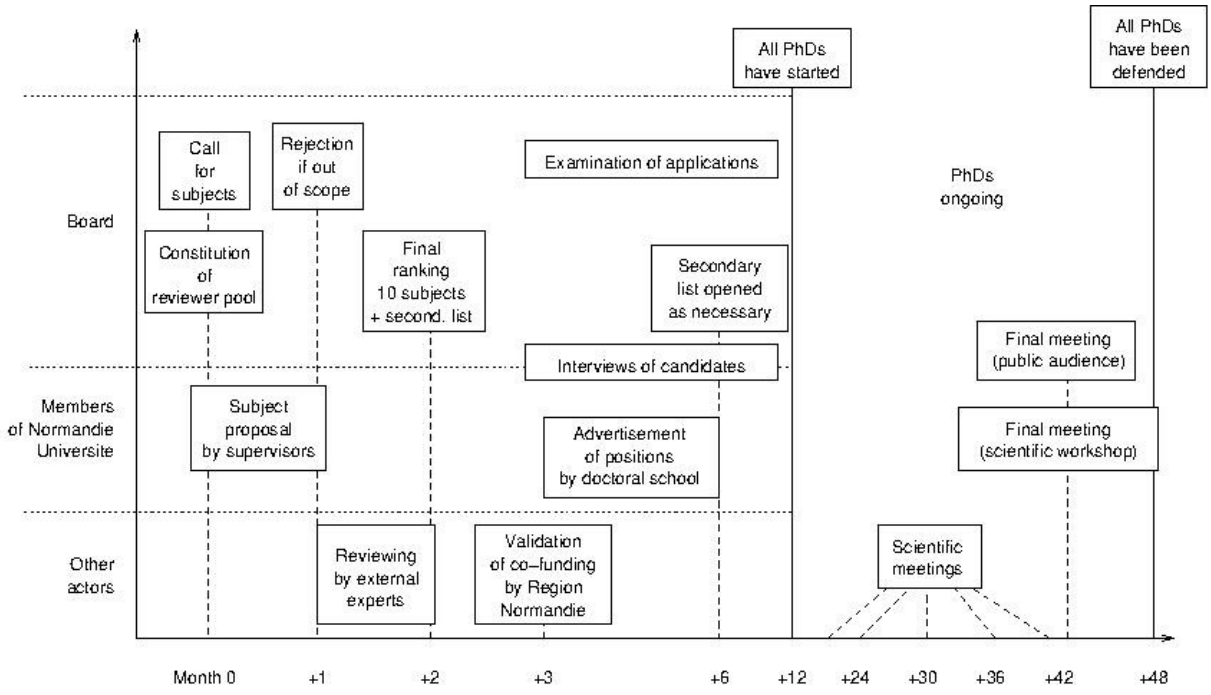

Figure 2. Summary of the program schedule.

The board will then rank subjects based on these reviews, while maintaining a balance between subjects reflecting the two axes of this proposal. A main list of 10 subjects, and a secondary list will be constituted. These lists will be sent to Région Normandie for validation of the co-funding. Moreover, for transparency, **the reviews will be sent to all researchers who have proposed a subject**.

Once this process is done, funded subjects and the secondary list will be advertised by all means, including a dedicated web page describing the overall program HAISCoDe, under the responsibility of the doctoral school MIIS. Supervisors will proceed to preselection of candidates. So as to maximize chances to attract excellent candidates, there will be no strict deadline for this part: when a supervisor finds a good candidate, the board will examine the application (see below). If the candidate is indeed validated at this step, the PhD will start as early as possible. So as to maximize **attractivity at the international level**, all subjects and the overall program will systematically be advertised in English and towards laboratories and institutions in France and abroad; this will be done using the specialized mailing-lists of the scientific communities, dedicated platforms such as Euraxess, and the numerous contacts of individual researchers in other institutions.

Nevertheless, if at some point (for instance mid-September, 2020, depending on the actual starting date of the project) no suitable candidate has been identified for a particular subject in the main list, applications will be considered for the first subject in the secondary list as well, and so on.

This process is essentially the one used successfully by the SN cluster and the doctoral school MIIS for several years. This process is known and accepted by potential PhD supervisors, transparent, and consistent with the policy of Région Normandie. Moreover, we already have a large panel of external

These fees will not be funded by the present program.

reviewers who were already involved in the past, which will facilitate the constitution of the reviewing committee for this program.

For a given candidate, the board described above will first examine her/his application based on curriculum, transcripts, research experience, and recommendation letters. If the application is valuable in this respect, **an interview will be organized** (through videoconferencing if needed) with at least the supervisor, a representative of the board and one of doctoral school MIIS, both not involved in any PhD funded by this program, and, whenever applicable, representatives of the doctoral schools and/or clusters corresponding to the co-supervisor. The interview will help evaluate the motivation of the candidate and its understanding of the scientific domain and the subject.

Only excellent candidates will be selected. We indeed chose in this project to ask for cofunding of a reasonably small number of PhDs so that excellent candidates should be found for all the subjects.

Gender equality will be promoted by the board, by choosing women whenever two applications have equivalent overall assessments. Note that there is a 30/70 % ratio of female/male PhD students currently in the doctoral school MIIS, despite the fact that the school's scientific perimeter is in mathematics, computer science, and engineering.

5. Co-funding justification (1 page maximum)

Co-funding of 500 k€ (50 k€ per PhD) will be provided by Région Normandie, as part of its larger program for funding PhD theses through its five strategic axes (RIN). This larger program, involving complete (100 %) and partial (50 %) funding, has been in place for three years in the joint Normandie territory.

Together with co-funding by the ANR, each PhD will hence receive a 100 k€ funding. Given that the total salary cost for a PhD is slightly less than 95 k€, each PhD will receive an additional support of around 5 k€. We plan to use this support according to the following rough estimation, under the control of the supervision team described in Section 2.2:

- installation (laptop, books): 1 000 €,
- support for a long stay in another lab, possibly abroad: 1 500 €,
- invitations of other researchers, especially for the biannual workshops: 1 000 €,
- support for travelling to conferences: 1 500 €.

This support will allow the students to benefit from a facilitated integration in the research community, through stays in other labs and invitations of researchers. Travelling to conferences and other expenses will also be supported by the laboratories and the doctoral school MIIS.