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Toulouse Midi-Pyrénées

ANITI
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ANITI DAY

LIST OF PHDS AND POST-DOCS

ANITI, Artificial and Natural Intelligence Toulouse Institute, is the interdisciplinary institute of artificial intelligence in Toulouse. ANITI's activity is based on 3 main pillars: scientific research, training and contribution to economic development.

Its specificity is to develop a new generation of so-called hybrid artificial intelligence, combining in an integrated way machine learning techniques from data and models making it possible to express constraints and to perform logical reasoning.

Bringing together around 200 researchers from universities, engineering schools and scientific and technological research organisations in Toulouse and its region, and around fifty partners. The targeted strategic application sectors are mobility and transport and robotics / cobotics for the industry of the future.

The major challenge is to promote exchanges between industrialists who address their issues to scientists and academics to develop new markets and new technological applications.

ANITI is part, with Grenoble, Nice and Paris, of the four interdisciplinary institutes of artificial intelligence (3IA) which are set up for a renewable period of 4 years within the framework of the Investments for the future program of the Villani plan. These institutes will work in a network with the aim of making France one of the world leaders in artificial intelligence.

IP - A

ACCEPTABLE AI

Developing AI to Improve Global Governance

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Keywords : AI Governance, Digital Twin, Participation Systems

About me...

My name is Carlos, I'm a chilean self-taught programmer. I studied industrial engineering and I worked more than 3 years building data visualization platforms for open data for different countries. On 2019, five days after the emergence of the social outbreak in Chile, I participated in a team of developers that created a crowdsourcing platform to prioritize citizen demands emanating from social media and think tanks called Chilecracia (https://chilecracia.org). This platform, based on the comparison of pairs of proposals, built priority ranking using different algorithms, among which TrueSkill, developed by Microsoft for the ranking of players on the Xbox, stood out. This experience creating this tool encouraged me to study more deeply how digital platforms can improve our governance.

Abstract of the project

This project will study different online participation systems for direct and augmented democracy. On the one hand, I will analize participation platforms based only on the replacement of manual processes with technology-for example electronic voting- and how these systems have faced ethical, security, accessibility dilemmas, among others. On the other hand, the main goal of this thesis will be the contribution to the debate on how direct democracy platforms will transition to augmented democracy systems, contributing with empirical evidence on how a digital twin or token of a citizen can actively participate in these participation platforms, where the person only generates corrective measures of their preferences. In both cases, I will build open source tools that will support the developer community around the world to create their own instances of e-democracy both locally and governmentally, based on both concepts of democracy.

Empowering Data-driven AI by Argumentation and Persuasion

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Keywords : Explainable AI, Formal Evaluation, Argumentation

About me...

I recently graduated from INP Toulouse - ENSEEIHT in Informatics and Applied Mathematics after validating my end-of-studies research internship at the National Institute of Informatics (NII) of Tokyo. During this internship, I worked on explainability techniques and proposed a method [1]of evaluation of the performance of ML models that was published in IEEE AITest 2020. I also graduated from the University of Amsterdam in Security and Networking in 2017 where I did my first steps in research and in Machine Learning. These experiences abroad raised my curiosity for other cultures and I chose to work at ANITI to keep on meeting new people and discovering new cultures.

Abstract

Machine Learning has recently shown ground-breaking results in numerous tasks. However, at least as many questions arise from these new applications. Machine Learning models are well-known for their accuracy which tends to beat humans at many tasks. Thus, in some domains, where the decisions matter the most and errors are critical, results have to be understood and guaranteed to take further action. However, it seems that most accurate models do not provide any transparency to the user. This last statement is to be taken with a pinch of salt since this accuracy-interpretability trade-off [2] is called "a myth" in Rudin et al. [3].

The AI community has recently made a tremendous effort on proposing explanation techniques [4, 5, 6] to support, understand and certify Machine Learning (ML) model's decisions. Articles in the literature sometimes use different concepts such as interpretability and explainability in interchangeable ways. However, Lipton et al. claim that the term interpretability is ill-defined in [7]. Explainability techniques come in every shape and form and researchers use a wide variety of metrics to support their results. And this literature comes with a long list of desiderata for explanations. In this research effort, we review the community's desiderata for ML Interpretation methods and how we can link those to our goals Then, we aim at providing a formal framework to rigorously evaluate as many explainability techniques as possible. The framework should be abstract enough to cover the widest range of techniques as possible while proposing a refined and relevant formalization of the concepts defined by the explanation techniques. Finally, we will try to propose our own explanation method and compare the current state-of-the-art techniques to our method thanks to the formal framework.

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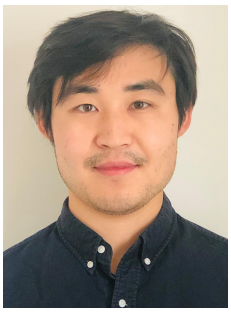

Explaining Learning Agents

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Integrative Program	IA acceptable

Keywords : Causality, Causal Equation, Classifier, Modal Logic

About me...

I am a PhD student in ANITI of Toulouse. I graduated in the department of philosophy in the University of Munich (LMU). My master thesis was intuitionistic conditional logics under the supervision of Dr. Ciardelli at the Munich Center for Mathematical Philosophy (MCMP) on. Therein I constructed and investigated the intuitionistic counterpart of some mostly used conditional logics. The close relation between conditional logic and causal explanation brought me to the interdisciplinary project of ANITI on explainable AI.

Abstract of the project

Very broadly speaking, my approach belongs to the endeavor of offering causal explanations for XAI. A simple argument is that when we ask for an explanation, it always takes the form of a why-question, and yields a because-answer. More concretely speaking, the short-term target is to investigate the work of [1] which gives reasons to classifiers. We are thinking of reformalizing it into the ceteris paribus logic [2]. The long-term objective is to generalize the reformalization to causal equation in [3], so that the current work of causal explanation for XAI can be converged into the field of multi-agent epistemic logics.

References

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Deep generative models for Monte Carlo sampling

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Keywords : Deep Learning, Bayesian inference, Monte Carlo algorithms, Machine Learning

About me...

I am a 1st year PhD student at ANITI. I recently graduated from a Master degree in applied mathematics and statistics at ENSAI. This follows a double degree in Computer Science engineering at ECAM Lyon and an MBA in Finance at IGR. Throughout my scholar's path, I had the opportunity to carry out several missions in the industry. During my last experience as a Research Scientist I worked on deep neural networks applied to time series. My enthusiasm for machine learning led me to pursue my research at ANITI on Acceptable AI.

Abstract of the project

Numerous machine learning and signal/image processing tasks can be formulated as statistical inference problems. However, misspecification or underspecification of the probabilistic model describing the data set and how it relates to the parameters of interest impair most of the statistical inference methods. To overcome this difficulty, this project aims at developing new inference frameworks able to embed data-driven models into statistically sound approaches and methods.

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Pseudo Boolean Learning for reasoning on graphic models

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Keywords : Optimization, Weighted Constraint Satisfaction Problem, Learning, Pseudo-boolean constraints

About me...

I'm freshly graduated from the engineering school Polytech Clermont ferrand with specialty mathematics and modeling, I also obtained a master's degree in Computer Science at the university of Clermont-Auvergne. I oriented myself toward research after two rewarding internships, one in 2019 at Kumamoto University, and one earlier this year at INRAE. In the first one, under the supervision of CHIBA Shuya and in collaboration with a Japanese student MISHIO Eishi we manage to prove a theorem in graph theory. Basically if a directed graph is sufficiently large and connected we proved the existence of a particular spanning subdigraph (a directed path-factor), you can find more information on the paper we published after the internship [1]. The second internship I did was with Simon DE GIVRY and George Katsirelos (my actual PhD supervisors) at INRAE, the goal was to improve Toulbar2, an optimizer for cost function networks and discrete additive graphical models. I had to propose an algorithm well suited to Toulbar2 to cope more efficiently with linear constraints. I then implemented it to Toulbar2 and launch some benchmarks to verify it's efficiently, we noticed some nice improvement on some kind of problems. We are pushing further this result in my PhD. Here is the source code of Toulbar2 : https://github.com/toulbar2/toulbar2.

Abstract (∼300 words)

Graphic models are information representation tools capable of supporting both logical and probabilistic information. They therefore lend themselves well to the treatment of problems requiring the integration of data (learning), by estimating a probabilistic graphic model from data (via the classical principles of penalized maximum likelihood or maximum margin) and logical properties (constraints).
In the specific case of problems representing only logical information, a simple but extremely effective mechanism called "conflict-directed learning" [2] is used by many of the most effective proofs (SAT solvers, CSP). Starting from a conflict observed during a tree search, they are able to produce information (constraint) that is a logical consequence (a relaxation) of the whole problem, which can then be exploited to facilitate the resolution of the original problem.
The aim of the thesis is to generalize this learning mechanism in the case where numerical information possibly estimated from data (such as probability/energy or cost) is available in addition to logical information.
If we want an effective algorithm we need to be particularly attentive to the following points :

1. it is necessary to define precisely the mechanism to learn pseudo-Boolean constraints in conflict situations, in particular by selecting an optimal (but probably heuristic) way to choose the best pseudo-Boolean constraint(s) to keep.

2. this mechanism should ideally be able to work with the different types of local coherence used so far in graphical models [3], both simple local coherence (arc coherence, bounded max-resolution) but also, in the longer term and in principle at least, on algorithms running on so-called global (or higher order) functions.

3. efficient mechanisms for taking into account the information generated during the resolution, to speed up research. This is quite immediate in the case of logical proofs, because the logical consequences can be immediately added to the problem to be solved. The numerical case is significantly more difficult, because the information learned is not of the same nature as the information present in the graphical model.

4. a mechanism for selecting the most relevant learned information, which is kept over time or, on the contrary, forgotten. Indeed, producing an excessive amount of information learned from conflicts can ultimately have a counter-productive effect, slowing down the search.

References

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Learning Representations for spatial data

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Integrative Program	IA acceptable; IA certifiable

Keywords : Representation learning, Anomaly Detection, Few Shot learning, Optimal Transport, Robustness.

About me...

I am a PhD student in ANITI. I learned to program as an autodidact in high school through algorithmic competitions. Then I moved on projects involving artificial intelligence for games or combinatorics because I was fascinated by solving complex problems with machines. It led me to integrate l'Ecole Normale Supérieure de Lyon, from which I graduated with a Master in Fundamental Computer Science (speciality complex systems).

I got the chance to work with researchers in different laboratories such as INRIA, Google Brain, ENS Lyon, MILA or IMT Atlantique during my search internships. I worked on various topics related to Deep learning, such as Graph Neural Networks, Reinforcement Learning or Few Shot learning.

Abstract of the project

Objects such as images of temporal series lie in high dimension space where euclidean carries little to no information on semantic proximity between the classes. It makes any method based on nearest neighbors inefficient. Building representations in an unsupervised way can circumvent this issue. Working in the latent space allows few shot learning or anomaly detection. Some popular methods in the field involve Mutual Information maximization [1] or Variational Autoencoder (VAE) [2].

More specifically I focus on the usage of provably 1-Lipschitz neural networks and their applications to anomaly detection, by formulating the out of distribution detection as an optimal transport problem. It is a natural extension of the work done in [3] (involving my thesis director Mathieu Serrurier and the chairman Jean Michel Loubes, among others). The properties of 1-Lipschitz functions guarantees some robustness against adversarial samples. It can be similarly understood as maximal margin classification in a Banach space [4].

Benchmarks will be conducted on satellite data of Thalès Alénia Space, from the team of Marc Spigai.

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Smart Encoding of 3D Meshes with Deep Learning. Application to Aeronautic Assisted Design

FOY

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Integrative Program	Acceptable AI (IP-A)

Keywords : Autoencoders, Latent manifolds, Topological data analysis (TDA), Computational fluid dynamics (CFD)

About me...

I just graduated from Centrale Lyon and am going to start an ANITI PhD at Université Paul Sabatier (Toulouse 3). I majored in numerical analysis and I also graduated from a research master in data science at Université Claude Bernard (Lyon 1). During my studies I had the opportunity to work in Ukraine as a research assistant and in Singapore and Bangalore (India) as a data engineer. I like traveling, photography and all kinds of sport.

Abstract (∼300 words)

In the context of turbine blade modeling we aim to provide a fast estimation of an expensive numerical simulation. Neural computing is well suited for such an objective. Nevertheless, one very important issue relies on the way the physical model is encoded for learning. This PhD consists in developing learning methods for the representation of 3D graphs (or 3D point clouds) using unsupervised deep learning approaches. These representations must be smart in the sense that they should not only describe the 3D mesh of the part, but also extract influential parameters or parameters that allow the part to be deformed according to predefined transformations. These representations can also be used, for example, to retrieve mechanical information about the part or the thermodynamic and aerodynamic behavior of the fluid around the part. The question of the inputs to add to the network will also be addressed, indeed in 2D the addition of a Signed Distance Function (SDF) to the geometry provides considerable significant to the pixels far from the geometry [1]. Other less traditional inputs such as the topological persistence diagram and how to integrate it into the network will also be studied. The persistence diagram [2], [3] furnishes a topological an helpful description for the collection of level sets of an abstract real valued function. Roughly speaking, the persistence diagram describes the dynamical branching of an half line preimage when the threshold is moving. It has been shown that incorporating this information as additional features drastically improves the performance of learning algorithm [4]. In this Ph.D thesis, we will experiment and put in action such methods in the context of physical simulations.

References

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Sensitivity Analysis for Fairness-driven Machine Learning

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Integrative Program	Acceptability and Certifiability for IA

Keywords : Fairness, Global Sensitivity Analysis, Machine Learning

About me...

I am Clément Bénesse, a second-year Ph.D. at the Artificial and Neural Intelligence Toulouse Institute (ANITI). I obtained my Master's Degree in Theoretical Statistics from a joint Masters program supervised by the École Normale Supérieure de Lyon (France) and the University of Lyon (France). My research interests include topics related to Fairness and Global Sensitivity Analysis in a Machine Learning framework. I am currently working on a probabilistic framework using Sensitivity Analysis for better definitions of Fairness.

Abstract of the project

Quantifying the influence of a variable on the outcome of an algorithm is an issue of high importance in order to understand decisions and detect unwanted biases in the decisions that may lead to unfair predictions. The recent development of the literature on Fair learning for Artificial Intelligence [1] shows how essential this problem is. One of the main difficulty lies in the definition of what is (un)fair and the choices to quantify it. Conversely, Global Sensitivity is used in numerous contexts to monitor the influence of any feature on an output variable. Multiple set of indices have been proposed over the years [2] and the flexibility in the choice allows for deep understanding in the relationship between a feature and the outcome of an algorithm. Our works reconcile these two domains by showing how Fairness can be seen as a special framework of Global Sensitivity Analysis and how various usual indicators are common between these two fields.

References

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Fair & Explainable AI using Counterfactual Models

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Integrative Program	IP-A

Keywords : Fair learning, counterfactual reasoning

About me...

I have an Engineering degree from Ecole polytechnique and a master degree in Applied Mathematics from Paris-Sud University. I did a research intership supported by ANITI during the first lockdown, and I started my PhD in September under the supervision of Jean-Michel Loubes (IMT), Laurent Risser (IMT) and Nicholas Asher (IRIT). My research is funded by Ecole polytechnique and co-funded by ANITI.

Abstract (∼300 words)

As a result of their increasing predictive performance, the application of machine learning algorithms to assist or even replace human decisions spread in various tasks such as finance, insurance, health-care, retail, defect detection and law. However, their massive use caused ethical issues in our society, in particular regarding the growing lack of interpretability and the potential harm toward minorities [1, 2]. With the expansion of so-called *black-box* models, there is an urgent need for machine learning researchers to develop practical methods to assess the partiality of complex decision rules. We try to analyze the fairness of an algorithm through the prism of counterfactual reasoning, which requires to understand outcomes in alternative states of things [3]. More specifically, our goal is to design frameworks to assess for any individuals what would have been the outcome had they belong to a different population (e.g. women and men). Should this phenomenon put a population at a disadvantage, this would be a sign of unfairness of the decision rule. The main gain of this method, compared to the study of mere fairness scores, lies in the possibility to analyze which features changed the most between such paired individuals, shedding light on the reason behind the discrimination. Prior research on the subject include the use of causal inference [4] and optimal transport theory [5].

References

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Artificial Intelligence for Ecosystem Monitoring using Remote Sensing and Digital Agriculture Data

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Keywords : remote sensing, environment, artificial intelligence, large scale gaussian processes

About me...

I graduated in Automation and Electronics from the Institut National des Sciences Appliquées (INSA) of Toulouse in 2019. During that period, in addition to my formation, I did a volunteering mission in Laos, a summer school "International Economy and Sustainable Development" in Vienna (Austria), an Erasmus in Glasgow (Scotland, UK) and two internships: one in the ONERA laboratory and the other in the startup EasyMile, both in Toulouse. After obtaining my engineering degree, I did a civic service for one year within a scientific mediation association (Science Animation) in Toulouse.
Since September 2020, I am a PhD student in the CESBIO laboratory, co-supervised by Mathieu Fauvel and Jordi Inglada. The subject is "Artificial Intelligence for Ecosystem Monitoring using Remote Sensing and Digital Agriculture Data". It is co-funded by CNES-CS and it is part of the ANITI Chair "Fusion-based inference from heterogeneous data" held by Nicolas Dobigeon.

Abstract (∼300 words)

The CESBIO laboratory produces the land cover maps of Metropolitan France every year since 2016 (`http://osr-cesbio.ups-tlse.fr/~oso/`). This map gives information on different types of physical cover of the Earth's surface, e.g. forests, grasslands, croplands ... It is based on the classification of Sentinel-2 satellite image time series. My PhD has 2 main challenges :

1. Large scale spatial data. The Sentinel-2 mission provides multi-spectral images with a high revisit frequency (every 5 days). Therefore, a huge number of data is available. Depending on climatic conditions, the same kind of cover in different locations can behave differently in terms of reflectance (spatial variability).
2. Integrate heterogeneous data into learning algorithms. These data can differ by their source (optical data, RADAR data, meteorological data, ground data) and but also by their spatial scale (different resolutions).

For now, I am going to focus on the problem of spatial variability. The current solution consists in using a spatial stratification according to some eco-climatic conditions. Then, the prediction function is optimized independently for each spatial region. Such stratification reduces the spatial variability and the size of the data to be processed. However, no spatial constraints are imposed and the models could behave differently at the spatial region boundaries. My work is to develop a learning strategy that ensures a smooth transition between two spatial regions (i.e., ensure similar predictions for models at boundaries). One naive approach may be to learn each model independently and merge the predictions using spatial constraints. Another approach is to include specific spatial constrains in the learning step. In particular, I am currently considering equality constraints for model predictions between pairs of adjacent regions.

Spiking Neural Networks for Auditory Processing (SNNAP)

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Integrative Program	IP A-C

Keywords : Spiking Neural Networks, Speech Recognition, Surrogate Gradient

About me

Ismail is a first year Ph.D. student at Paul Sabatier University in the Artificial and Neural Intelligence Toulouse Institute (France). He is holder of a Masters Degree and an Engineering Degree in High Performance Computing and Big Data from ENSEEIHT engineering school (France) in 2020. He is interested in learning methods for spiking neural networks.

Abstract

Neurons in a spiking neural network (SNN), as biological neurons, exchange information asynchronously using discrete electrical impulses. Recently it has been shown in [1] that one could successfully train a spiking neural network using known gradient-descent-based techniques and this through overcoming the non-derivable nature of spiking neurons dynamics by using a surrogate gradient method. In addition to offering a more bio-plausible solution to the process of inference, spiking neural networks turn out to be a less expensive alternative to common artificial neural networks in terms of energy cost and that by taking advantage of the scarcity of spikes and the sparseness of synaptic operations. SNNs could also become an almost mandatory solution, as pointed in [2], for offline and embedded systems using neuromorphic computing and where predictions should be made locally without resorting to external resources. Our aim is therefore to improve the precision as well as the energy cost of SNNs for tasks linked to sound data such as classification of sounds, segmentation and recognition of phonemes, all based on former works consigned in [3].

References

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Argumentative Approach to Case-based Reasoning

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Keywords : Reasoning, Case Based, Argumentative

About me...

I am Vivien Beuselinck in the first-year of my Ph.D. at the Artificial and Neural Intelligence Toulouse Institute (ANITI). I obtained my Master's Degree in IA from University Artois. I studied Argumentation during my stage and i loved it. I choose to continue

Abstract of the project

Case-based reasoning (CBR) is an approach to problem solving and learning that has got a lot of attention over the last years. It is in many respects fundamentally different from other major AI approaches. Instead of relying solely on general knowledge of a problem domain, or making associations along generalized relationships between problem descriptors and conclusions, CBR is able to utilize specific knowledge of previously experienced, concrete problem situations (cases). A new problem is solved by finding a similar past case, and reusing it in the new problem situation. A second important difference is that CBR also is an approach to incremental, sustained learning, since a new experience is retained each time a problem has been solved, making it immediately available for future problems. The CBR field has grown rapidly over the last few years, as seen by its increased share of papers at major conferences.

Argumentation is a reasoning approach based on the justification of claims by arguments. It is a unifying approach for solving various AI problems including reasoning with inconsistent, incomplete and uncertain information, decision making, and classification. The argumentative formulation of CBR naturally allows characterising the computation of an outcome as a dialogical process between a proponent and an opponent, and can be used to extract explanations for why an outcome for a new case is (not) computed

IP - B

CERTIFIABLE AI

Hybridation of data assimilation and machine learning

Fillion

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Keywords : Bayesian data assimilation, information theory, machine learning, recurrent networks

About me...

Anthony Fillion is a PostDoc researcher in the Artificial Intelligence institute ANITI of Toulouse. He graduated in computer science and applied mathematics from INP-ENSEEIHT, a french engineering school. He did his PhD between Cerfacs (Toulouse) and CEREA (Paris) on Data Assimilation. His work focuses on Ensemble Variational Data assimilation algorithms. He developed during his PhD a method for solving the DA problem with model error (so-called weak constrained problem)[1]. He also introduced quasi-static approaches in those EnVar methods [2]. More recently he investigates the connection between DA and Machine learning, using recurrent neural networks and concepts from information theory [3].

Abstract of [3]

Data assimilation algorithms aim at forecasting the state of a dynamical system by combining a mathematical representation of the system with noisy observations thereof. We propose a fully data driven deep learning architecture generalizing recurrent Elman networks and data assimilation algorithms which provably reaches the same prediction goals as the latter. On numerical experiments based on the well-known Lorenz system and when suitably trained using snapshots of the system trajectory (i.e. batches of state trajectories) and observations, our architecture successfully reconstructs both the analysis and the propagation of probability density functions of the system state at a given time conditioned to past observations.

References

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Sensitivity Analysis for Fairness-driven Machine Learning

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Keywords : Fairness, Global Sensitivity Analysis, Machine Learning

About me...

I am Clément Bénesse, a second-year Ph.D. at the Artificial and Neural Intelligence Toulouse Institute (ANITI). I obtained my Master's Degree in Theoretical Statistics from a joint Masters program supervised by the École Normale Supérieure de Lyon (France) and the University of Lyon (France). My research interests include topics related to Fairness and Global Sensitivity Analysis in a Machine Learning framework. I am currently working on a probabilistic framework using Sensitivity Analysis for better definitions of Fairness.

Abstract of the project

Quantifying the influence of a variable on the outcome of an algorithm is an issue of high importance in order to understand decisions and detect unwanted biases in the decisions that may lead to unfair predictions. The recent development of the literature on Fair learning for Artificial Intelligence [1] shows how essential this problem is. One of the main difficulty lies in the definition of what is (un)fair and the choices to quantify it. Conversely, Global Sensitivity is used in numerous contexts to monitor the influence of any feature on an output variable. Multiple set of indices have been proposed over the years [2] and the flexibility in the choice allows for deep understanding in the relationship between a feature and the outcome of an algorithm. Our works reconcile these two domains by showing how Fairness can be seen as a special framework of Global Sensitivity Analysis and how various usual indicators are common between these two fields.

References

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Learning to play better

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Keywords : Game Theory, Matching with Learning, Online Optimization

About me...

I am a postdoctoral researcher in ANITI of Toulouse. I am from Argentina and as a "good" Argentinian, I came with my *mate* under my arm. I have recently finished my Ph.D. in Chile and I have worked mainly on Revenue Management problems. About my undergraduates studies, I am mathematician from Universidad de Rosario, in Argentina. Since I was very child I enjoy solving math problems that represent a challenge.

I arrived at Toulouse very recently and despite the particular situation we are living, I am very happy about starting this project. I love facing new challenges, and even more if they involve meeting new people and cultures.

About my everyday life, I am very friendly (although also a bit shy) and I love going out with friends. I like doing sports, and in particular I love hiking and climbing.

Abstract of the project

Although I am just starting my project, the idea is to combine game theory and artificial intelligence. How can we do it? Well, in every game, there are decisions that players should make according to the rules of the game. Depending not only on their own actions but also on the others, players obtain a payoff. Given that the goal of players is to maximize the payoff they obtain, if they know the actions the other players will take, the decision is very easy to take. However, this information is unknown and that is why studying different equilibrium concepts [1] as well as optimal mechanism design [2] have been gain a lot of popularity in Operations Research, Computer Science and Economy communities.

Therefore, being able to learn about the behaviour of players may help to find a good strategy in a game, and there is where artificial intelligence comes into play.

In particular, the project is focused on looking at some specific problems, such as the well known Secretary Problem [3] and the Online Matching Problem [4].

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Runtime Verification for Critical Machine Learning Applications

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Keywords : Runtime monitoring, Inference uncertainty, Safety

About me...

I received a Ph.D. in computer science and signal processing in 2018, from Arts et Métiers ParisTech, Lille, France. Before that, I received the diplôme d'ingénieur (equivalent to M.Sc. degree) from Arts et Métiers ParisTech and the M.Sc. in Industrial Engineering from Texas Tech University, both in 2015. In 2019 and 2020, I conducted postdoctoral research at Universidade Federal Fluminense and Universidade Federal do Rio Grande do Norte, Brazil. Since November 2020, I am a postdoc at ANITI, to work on runtime verification for critical applications containing ML. The central idea across my different research topics is that real-world systems containing ML components can benefit from understanding and incorporating specificities from the application domain. In particular, my research interest includes robotics perception, image clustering, reinforcement learning and person re-identification.

Abstract of the project

Recent Machine Learning (ML) methods have been used to address a wide panel of complex tasks. However, in general, the testing approach based on predefined datasets cannot provide sufficient guarantees that it will work properly in all real life situations (distributional shift, adversarial attacks), which is a major brake to use ML components in safety critical applications. To address these anomalous situations, it is not possible to focus only on improving the training process and data. Instead, a promising approach is to monitor the system at runtime, during operational life, in order to keep the system in a safe state, despite potential errors of the ML components. Some approaches propose to identify out-of-distribution inputs in ML models [1, 2], while others propose to include ML controlled systems into safety frameworks to avoid dramatic failures [3, 4]. The objectives of this postdoc are to specify, implement and verify a new runtime verification approach for ML based systems. Once such a monitor would be designed, we also plan to use formal methods (verification) to prove the correctness of the monitor. This work will be applied to a case study of drone collision avoidance.

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Conservative fields in machine learning

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Keywords : Nonsmooth stochastic optimization, First order methods, Automatic differentiation, Definable sets, o-minimal structures

About me...

I'm a first-year PhD student at ANITI working under the supervision of Jérôme Bolte (TSE) and Edouard Pauwels (IRIT). Previously, I graduated both from ENSAE Paris and ENS Paris-Saclay where I respectively obtained master's degrees in "Data Science, Statistics and Learning", and "Mathematics, Vision and Learning" (MVA). I did a 6-months internship supervised by Edouard Pauwels where I worked on the population risk convergence for the Stochastic Gradient Descent algorithm in a nonsmooth context.

The goal of my research is to obtain theoretical guarantees for optimization algorithms in machine learning. I use for instance tools from stochastic approximation, nonsmooth analysis and definable sets theory and I currently work on a notion of conservativity for set-valued functions.

Abstract of the project

Training modern learning architectures combines first order nonconvex optimization [1], subsampling approximation [2] and algorithmic differentiation which is an automatized numerical application of the chain rule of differential calculus [3]. These approaches are central in recently developped computational libraries such as Tensorflow [4] or PyTorch [5]. However these libraries implement algorithmic differentiation outside of its original domain of application, which is restricted to differentiable elementary operations .

Understanding the behavior of algorithmic differentiation and its impact on learning emerged recently as an important question in the machine learning community [6, 7]. The notion of conservativity for set valued functions [8] is flexible enough to model algorithmic differentiation in modern learning contexts and formulate learning guarantees in terms of attracting sets and stability of deep networks training algorithms as implemented in practice [8, 9].

The goal of this Ph.D. thesis is to investigate and extend the field of application of the notion of conservativity in a machine learning and deep network context. More precisely, we will investigate statistical and concentration aspects of algorithmic differentiation and their consequences for learning algorithms based on algorithmic differentiation.

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Learning Representations for spatial data

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Research lab	ANITI, IRIT
Integrative Program	IA acceptable; IA certifiable

Keywords : Representation learning, Anomaly Detection, Few Shot learning, Optimal Transport, Robustness.

About me...

I am a PhD student in ANITI. I learned to program as an autodidact in high school through algorithmic competitions. Then I moved on projects involving artificial intelligence for games or combinatorics because I was fascinated by solving complex problems with machines. It led me to integrate l'Ecole Normale Supérieure de Lyon, from which I graduated with a Master in Fundamental Computer Science (speciality complex systems).

I got the chance to work with researchers in different laboratories such as INRIA, Google Brain, ENS Lyon, MILA or IMT Atlantique during my search internships. I worked on various topics related to Deep learning, such as Graph Neural Networks, Reinforcement Learning or Few Shot learning.

Abstract of the project

Objects such as images of temporal series lie in high dimension space where euclidean carries little to no information on semantic proximity between the classes. It makes any method based on nearest neighbors inefficient. Building representations in an unsupervised way can circumvent this issue. Working in the latent space allows few shot learning or anomaly detection. Some popular methods in the field involve Mutual Information maximization [1] or Variational Autoencoder (VAE) [2].

More specifically I focus on the usage of provably 1-Lipschitz neural networks and their applications to anomaly detection, by formulating the out of distribution detection as an optimal transport problem. It is a natural extension of the work done in [3] (involving my thesis director Mathieu Serrurier and the chairman Jean Michel Loubes, among others). The properties of 1-Lipschitz functions guarantees some robustness against adversarial samples. It can be similarly understood as maximal margin classification in a Banach space [4].

Benchmarks will be conducted on satellite data of Thalès Alénia Space, from the team of Marc Spigai.

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Towards more efficient learning of physical dynamics using machine learning and data assimilation

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Integrative Program	Certifiable AI

Keywords : Data Assimilation, Latent space, Surrogate Network

About him...

He has just graduated in computer science and applied mathematics from INP-ENSEEIHT, a French engineering school in Toulouse. Last year, he did a 3 months internship at Wuppertal University (Germany) from June to August 2019: he implemented a new method to detect adversarial images crafted with Carlini & Wagner attacks based on counter attack principle [1]. More recently, he did his end of studies internship at ANITI (March to September 2020): the goal was to solve Burgers' equation using neural networks instead of classic solvers. The main challenge was to remain stable over time along with being accurate enough.

Since October 5th, he is working with Atos through a 6 months temporary contract which will turn into a CIFRE contract as soon as ANRT gives its agreement. This PhD involves 3 main entities: Atos, ANITI and CERFACS.

Abstract of the project

He will focus on the reduction of the computational cost of the learning process while maintaining the stability and the accuracy of the solution and relying on data assimilation. As shown in [2], being computationally efficient might imply reducing the spatial dimensionality with autoencoders and training a surrogate network within a latent space. There has been a significant increase in the research of using ML to forecast the evolution of physical systems with a data-driven approach. [3] use data-driven methods to represent the dynamics in a more explicit manner using nonlinear regression, and [4] mimic the numerical integration scheme by using NN. [5] recently propose to use a *Bayesian data assimilation* framework to infer ordinary differential equation (ODE) representations of dynamical models.

References

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Automotive Radar Interference Mitigation based on V2X and A.I.

Roudiere

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Integrative Program	IA Certifiable

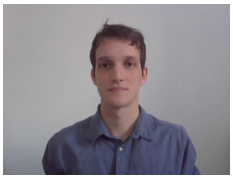
Keywords : Automotive, Interference Mitigation, Multi-Agent, V2X

About me...

Sylvain Roudiere is a PhD student in the Artificial Intelligence institute ANITI of Toulouse. He graduated as an engineer in Embedded Systems and Connected Object from INP-PHELMA, a french engineering school. After this degree, he decided to continue with the specialized master degree ValDoM on Data Science, as it was an interesting topic he discovered during its semester studying abroad in Sweden at KTH-Stockholm. He did its master thesis within the NXP-Semiconductor company where he applied its knowledge on A.I. to build a framework to simulate radar interference mitigation strategies in an automotive scenarios and evaluate the performance of A.I. strategies compared to classical ones.

Abstract of the project

Today we see the rise of ADAS (Advanced Driver Assistance Systems) for assisted and automated transportation systems. Such vehicles, drones or rovers heavily rely on different sensors, and radar is one of the most commonly used. Radar systems are sometimes classified as short-range, or long-range depending on the application targeted, which can be for example Automatic Cruse Control (ACC), Blind Spot Detection (BSD), parking, pedestrian detection. Still today, a low percentage of vehicles are equipped with such systems, but projections show that the number of radar system is increasing exponentially. By 2030, forecast is that 50% of the cars will be equipped with radar, representing 700 millions of vehicles, for a total of around 3.5 billion of radars systems in use. This leads to an increased risk of life threatening consequence due to radar interference. Radar interference may originate from a variety of reasons, including high density of signal sources, reflection on other objects, too high emission level, geometry, meteorological (wet road) or environmental (guard rails, tunnels) origins. The effect of interference can be dramatic, by nulling the signal sent by a source, or flooding a receiver by unwanted signal. Simple mitigation techniques may include statistical mitigation, detection of interference and repairing at signal processing level. More promising techniques based interference avoidance by means of coordination of the neighbor vehicles via a communication channel such as V2X (vehicle to everything) or 5G and the addition of A.I. for the decision making process are being investigated, and are the primary scope for this thesis.



Rounding errors and accuracy in neural networks

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Integrative Program	IP B

Keywords : rounding error analysis, floating-point arithmetic, probabilistic error bounds

About me...

I have just started my PhD at ANITI in October in collaboration with Atos. This thesis follows my internship that I started in March at ANITI. I graduated from ENSEEIHT with a speciality in applied mathematics.

Abstract

Deep network-based Artificial Intelligence technologies are revolutionising the design paradigm of many applications. We are moving from a model-based design approach, based on algorithmic logic, to a data-centric approach where it is much more difficult to explain proof of accuracy or confidence bounds. Machine learning methods and their software implementations are subject to rounding errors resulting from the use of finite precision arithmetic in the calculations. These errors can have a considerable impact on the robustness of AI methods and tools, defined as the ability to maintain correct behaviour in the presence of disturbances whose nature and origin are extremely varied. Moreover, it is common for inference to be made in an embedded environment with more constraining hardware than during training. The objective of this thesis is to develop numerical analysis methods and tools applicable in these different contexts to :

- Estimate the quality of prediction and the stability of neural networks.
- Understand what are the sources of errors and instabilities and thus to contribute to an explicable AI that allows us to trace the root cause of the errors.
- Be able to raise alerts when the result of a network's inference on a data is potentially dangerous or uncertain. And ultimately guide developers through the (meta)learning phases.

Higham et al. [1] have recently proposed probabilistic approaches for error analysis in linear algebra operations capable of producing much more precise bounds than "deterministic" (worst case) analyses [2] under the condition that rounding errors can be modelled as independent stochastic variables ; these bounds are respected with a very high probability [3]. This thesis therefore aims to extend these results and apply them to neural networks in order to obtain error bounds that will provide precise indications on the sources of errors in neural networks, on the quality of the result of an inference operation and on the robustness of a network.

References

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Integrative Program	IP B (Certifiable AI)

Keywords : Online learning, bandits, pricing

About me...

I got my undergraduate (*magna cum laude*) and master's (*magna cum laude*) degree in Math at the University of Milan, Italy. My master's thesis was titled "Online bandit convex optimization" and written under the supervision of Nicolò Cesa-Bianchi. Afterward, I was honored to have the opportunity to continue my path with Nicolò Cesa-Bianchi, completing a PhD in Computer Science at the University of Milan, Italy. During the three years of my PhD, I dedicated myself to theoretical aspects of dynamic pricing, cooperative online learning, repeated decision-making, and online non-convex optimization. My PhD manuscript, titled "Algorithms, learning, and optimization", consists essentially of a collection of these works. During my time in Milan, I had the pleasure of collaborating with exceptionally talented people, including but not limited to Vianney Perchet, Yishay Mansour, and last but not least, Sébastien Gerchinovitz, to which I am particularly grateful for introducing me to ANITI.

Abstract (∼300 words)

For references on the following papers, see below. During my first year with ANITI, I worked on two additional projects on cooperation in online learning, focusing more on the case of limited feedback. This is part of a joint work with Nicolò Cesa-Bianchi (University of Milan) and his group. Together with Sébastien Gerchinovitz (IRT, ANITI) and François Bachoc (IMT, University Paul Sabatier), I worked on the problem of approximating the level set of a black-box function with the smallest number of queries. I co-supervised a very bright master's student from the Math department of the University of Milan, Roberto Colomboni. Our joint work led to a paper on some relationships between the 1-Nearest Neighbor algorithm and the (geometric) measure-theoretic concept of Lebesgue point. During my second year with ANITI, I am mainly focusing on three new projects. The first one, with Sébastien Gerchinovitz and François, is on the relationship between different (and some new) formulations of sample complexity bounds for non-convex optimization. The second one, with Stefano Leonardi (University of Rome), Federico Fusco (University of Rome), Nicolò Cesa-Bianchi, and Roberto Colomboni is on the regret analysis of bilateral trading. Finally, together with Ilja Kuzborskij (DeepMind), I am studying some convergence properties of the training error of the Gradient Descent algorithm for overparameterized neural networks.

References

See my Google scholar page.

Tractable Function Representations for Explainability

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Keywords : Explainable AI, Automated Reasoning, Logic & Verificiation

About me

Xuanxiang Huang is a Ph.D student at ANITI, University of Toulouse. He received M.Eng. degree in Department of Computer Science from Jinan University, Guangzhou, China, in 2019. His research interests lies in explainable AI(XAI), logic & verification and automated reasoning. His previous research focuses on Binary Decision Diagrams (BDDs) and their variants for representing Boolean functions in compact and canonical way.

Abstract

His current research is to explain decision trees which compiled from machine learning models[1], and enumerate (prime implicant) explanations[2, 3] of decision trees in order to help human better understand decisions made by machine learning models.

References

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IP - C

COLLABORATIVE AI

Modeling shift from efficient to inefficient divided attention using EEG/fMRI/MEG

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Keywords : Brain connectivity, Electroencephalography, Inverse Reinforcement Learning (IRL)

About me...

After obtaining an International Baccalauréat, I did a Bachelor's degree in Biomedical Engineering at the University of Rouen where I studied broad subjects going from biology, thermodynamics, physics and pathology, to statistics, mathematics and computing. I then went to Paris to obtain a Master's degree in Bioengineering and Innovations in Neuroscience from the ESPCI and University Paris-Descartes. From there, I moved to a PhD in Cognitive Neuroscience during which I assessed the neurofunctionnal correlates of automated system supervision in highly automated environments (i.e. aeronautics) and the electroencephalographics markers of system error detection and performance monitoring in order to understand the out-of-the-loop phenomenon. I obtained my PhD from the Université Grenoble-Alpes in December 2018. During this PhD I specialized in EEG and signal processing. I then started a Post-Doc at ISAE-Supaero on neural correlates of inattentional deafness in ecological contexts (e.g., flight simulation, real-flight) with mobile EEG where I improved my computer skills in machine learning. Finally, I started the ANITI post-doc in February 2020.
Apart from research, my hobbies cover running in a club (and sports in general) and travelling. I also like going out with friends, playing video games, board games and going to the movies.

Abstract (∼300 words)

In our everyday-life, we are constantly solicited by multimodal stimulation. Changing from one modality to the other in multitasking environment relies on our selective attention capacities. Two main pathways have been identified for dynamical and efficient processing: a low level, or bottom-up, ventral processing pathway and a high level, or top-down, dorsal one. Yet attentional resources are known to be limited with a specific pool associated with each modality (visual, auditory, somatosensory), but also a supramodal control pool acting as a filter for relevant and non-relevant information for the task at hand [1, 2]. When stimulations are too complex, prolonged, or under altered cognitive states (fatigue, stress, etc.), these pools might not be enough and excessive focusing on one modality at the expense of others can occur (e.g., in attentional deafness or blindness). As most reasearch on selective attention has focused on unimodal contexts, the networks involved in selective intermodal attention are still not well defined.
In this context, the goal of this project is to understand the neural correlates of divided attention and intermodal attentional switching, but also to identify networks involved in efficient and inefficient switching. To this aim, we are using EEG frequency measures of continuous selective attention (steady-state potentials; [3]) in a complex audio-visual attention switching task. The complexity of the task allows to draw both efficient and inefficient switches. The first processing step allows to determine, through EEG connectivity measures, the networks involved in these switches.

A second step will be to determine how experts (i.e. good performers in this complex task), enroll these networks. For this Inverse Reinforcement Learning algorithm will be used on EEG data, in order to determine the Reward Function associated with the MDP modeling attentional switching. Finally, an ultimate goal would be to use this expert reward function as a target during real-time operator state evaluation.

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Brain inspired generative models of out-of-distribution generalization

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Integrative Program	IA Collaborative

Keywords : Bio-inspired, Neuro-science, Generative Models, Out-of-distribution generalization

About me...

I am Victor Boutin, a Postdoctoral Research Associate at the Artificial and Natural Intelligence Toulouse Institute (ANITI). I received a Ph.D in computational neuroscience and artificial intelligence from Aix-Marseille University (France) in 2020 and a MSc in Statistics and Applied Mathematics from Ecole Centrale (France) in 2011. My research interests include topic related to Computer Vision, Generative Models, Neuro-Inspired Machine Learning. I am currently working on modeling the primate visual systems using Generative and Reccurent algorithms.

Abstract of the project

What brain mechanisms allow primate vision to generalize beyond training distributions to novel, out-of-distribution, image degradations? An increasingly large body of cognitive neuroscience literature points to a critical role for cortical feedback as a key mechanism to help solve difficult recognition problems [1, 2]. One of the most prominent theories of neural computations, called the Predictive processing, suggests that brain acts as recurrent and generative model. In this framework, higher layers of processing predict lower layers based on a-priori knowledge [3, 4]. I am currently working at implementing such models, and I wish to demonstrate that these mechanisms allow out-of-distribution generalization abilities [5].

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PhD in Robotics

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Integrative Program	IP C

Keywords : Human-robot interaction, Neuro-cognitive Robotics

About me

I am a cognitive scientist interested in research topics in cognitive and neural robotics, human-robot interaction, psychology, artificial intelligence, 4E cognition, and computer vision, among others.I graduated in Psychology (2004), in Computer Science (2008), and received a Master degree in Instructional Psychology (2007) from Universidad Central de Venezuela (UCV). Then, I obtained a Master degree in robotics (2012), and did my Ph.D. degree in robotics (2016) in the Ecole Centrale de Nantes (ECN), France. I have done postdoctoral research in bio-inspired underwater robotics (Federal University of Rio Grande, Brazil, 2016), in cognitive neurorobotics (Okinawa Institute of Science and Technology, Japan, 2018), and recently I joined as a postdoctoral researcher the ANITI chair of Cognitive and Interactive Robotics. Other than the academic activity, I am interested in skateboarding, musical composition, and I enjoy nature and wildlife.

Abstract

Our collaboration is at its early stage and could be devised into two main axis of developments. In the first axis, we are interested in exploring the decisional dimension of human-robot interaction from inspiration in studies of human cognition. Research subjects that are very interesting to us in this line consist in investigating the dynamics of interaction, and forms of coupling and emerging communication and understanding within it (e.g. the concept of intersubjectivity [1]). Thereby, our activities consist in designing, implementing, and testing prototypes for the control of the robot from the exploration of interdisciplinary literature in 4E cognition, developmental psychology, and philosophy of mind research [2], among others. The second axis consists in modeling and taking into account the human behavior in the interaction. Here we expect to abstract models of the human considering not only observable behavior, but also tracking hidden states from theoretical models that are very related to the quality of the interaction, such as the human motivation and engagement in the interaction activity [3]. We expect to evaluate how the robot enactment in the task can influence the human within the interaction scenarios.

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Integrative Program	IA Collaborative

Keywords : Computer vision, Action recognition, Human behavior analysis

About me...

I joined ANITI as a post-doc this summer. Before that, I obtained my Ph.D degree from University of Lille, and engineering degree in 2016 from National Institute of Applied Sciences and Technology (INSAT) in Tunisia, back home. I'm generally interested in computer vision applications involving human behavior analysis. For instance, my Ph.D focused on the classification and generation of human motion such as 3D actions and 2D facial expressions, by applying different coding techniques on non-linear manifolds to represent the data [1].

Abstract of the project

Self-supervised learning has become a popular technique with its ability to avoid the cost of annotating large-scale datasets. It suggests defining pseudo-labels from the data for supervision and uses the learned representations for different downstream tasks. Specifically, self-supervised contrastive learning has recently shown impressive results in several computer vision tasks involving image and sequential data [2]. In this context, we are addressing the problem of unsupervised action recognition from 3D skeletons and propose a self-supervised contrastive framework to learn robust action representations. We are studying a RNN encoder-decoder model and constraining its latent space with a contrastive learning approach that encourages transformed versions of a given input to be closer to each other in the latent space while distinct samples to be farther. Obtained results show that combining these approaches leads to larger gain in performance and tolerance to transformation than is achievable by any individual method.

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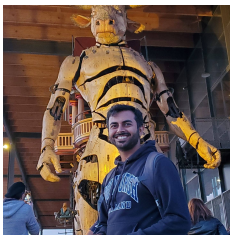

Learning what to learn where to attend

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Integrative Program	IA Collaborative

Keywords : Bio-inspired, Neuro-science, Attention, Visual Reasoning

About me...

I am Mohit Vaishnav in the second-year of my Ph.D. at the Artificial and Neural Intelligence Toulouse Institute (ANITI). I obtained my Master's Degree in Computer Vision and Robotics from the Erasmus Joint Masters program known as VIBOT, from the University of Bourgogne (France), University of Girona (Spain) and Heriot-Watt University (UK) in 2019. My research interests include topics related to Computer Vision, Neural Networks and Machine Learning. I am currently working on modeling attention and mnemonic mechanism inspired by biological systems.

Abstract of the project

Feedforward neural networks are now achieving superhuman accuracy in various image categorization tasks including face recognition, object recognition, and scene parsing. However, these same architectures struggle to learn basic visual relations such as judging whether two or more items in a visual scene are the same or different. Here, we use the *Synthetic Visual Reasoning Test (SVRT)* [1] challenge to identify the minimal set of neural computations necessary to solve all 23 visual reasoning problems. Our results lead to a refinement of the visual reasoning taxonomy found by (Kim*, Ricci* & Serre, 2018) [2]. In particular, we identify clusters of tasks that require spatial attention, some that require feature-based attention, and some that require both. Later on we would like to do the same for Visual Question Answering (VQA) [3, 4]

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Model Based Reinforcement Learning for legged Robots

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Keywords : Neuroscience, Bio-inspired Deep Learning, Representation Learning

About me...

I'm a second year PhD. student at ANITI. I obtained my Engineering Degree from CentraleSupelec (France) majoring in Computer Science. During my last year internship I gained interest in deep learning and fell in love with the idea of creating machine learning systems inspired from the brain. Since then, I have been exploring neuroscience and deep learning. Aside from that, I'm a simple guy, I like travelling, hiking in nature and skateboarding. I would love to try surfing at some point in the future.

Abstract of the project

My research focus over this year ranged from neurally inspired architectures to studying learning rules and objective functions in self supervised learning.

In preliminary work, we proposed a recurrent neural network as a model for low level vision model for explaining a color perception phenomenon called "color constancy". This model is based on prior work in computational neuroscience. On top of competing with larger and deeper feed-forward models, it accounts for other interesting perceptual phenomena "color illusions", thus proposing a link between two seemingly disparate phenomena of visual perception: illusions and color constancy.

Recent work addresses learning signals in representation learning. Representations of perceptual input are hierarchical in the brain, Convolutional Neural Networks are a great example of hierarchical processing of information as models of vision. In this project, we study the impact of objective functions at lower levels of the representation compared to higher levels on representation learning in the context of self-supervised action recognition from 3D skeletons. We find that a weighted combination of lower and higher level objective functions lead to a higher action recognition accuracy. We also show that models trained on a combinations of these learning signals are more robust to spatial transformations than models trained on either separately.

My goal for the future is exploring how memory mechanisms influence representation learning.

Multimodal grounding for improved data generation

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Research lab	VanRullen's lab / Cerco / IRIT
Integrative Program	IP C

Keywords : Multi-modality, deep learning

About me...

I graduated from the ISAE-Supaero engineering school in Toulouse in 2019. I did my M2 internship with my current PhD supervisor in the Cerco neuroscience lab. I worked there on brain and AI word representation, which gave the flavor of my current PhD project, that focuses mainly on combining word and images representation to create more efficient algorithms. Benjamin Devillers and I have very similar topics and I collaborate with him on one of his projects.

Abstract

Translating latent representations

The current models (see fig. 1) that are used to process text or image create vectorized representation of the input they receive. Each of the vector spaces, which are called latent spaces, have interesting properties, such as linearity (for instance by adding the vector that represent king with the one that represent woman, and subtracting the one that represent man, the vector that represent queen is obtained [1]). The goal of this project is create a translator between an image latent space and a text latent space, using a database containing images of 200 species of birds and descriptions of these species [2].

Merging sequence data from multiple domains

Real-life data comes from multiple domains. We use all our senses to collect information and interact. Besides, the domains naturally come synchronized. This project Benjamin Devillers and I have been working on this last year is on merging sequences coming from multiple domains (or modalities).

Our initial focus is on tri-modal data. In particular, we are trying to encode videos of TED conferences. The videos contain a visual, an auditory and a textual domain (transcript of conference). See fig. 2 for an example.

For this, we took inspiration in the transformer-based multi-modal literature [3, 4, 5, 6, 7, 8] and in particular in ViLBERT [9] to merge the modalities together. The architecture (see fig. 3) is composed of two set of auto-encoders: uni-modal auto-encoders which encode the modalities separately and a multi-modal auto-encoder composed of one encoder and one decoder for each modality.

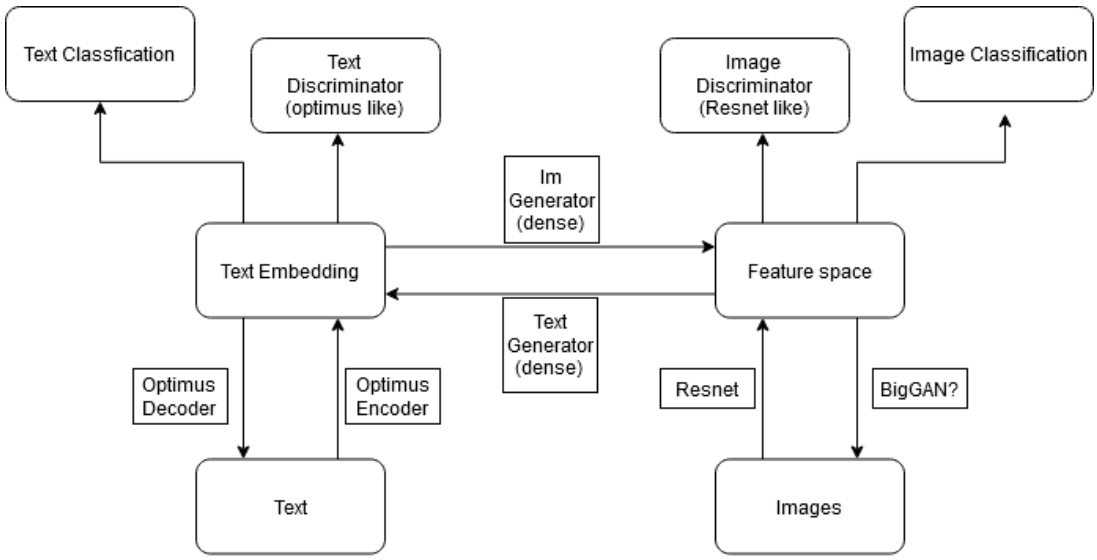

Figure 1: Architecture of the model.

Figure 2: Excerpt of an image sequence taken from the Lip Reading Sentences 3 (LRS3) dataset. Associated with the transcript "WHEN I WAS".

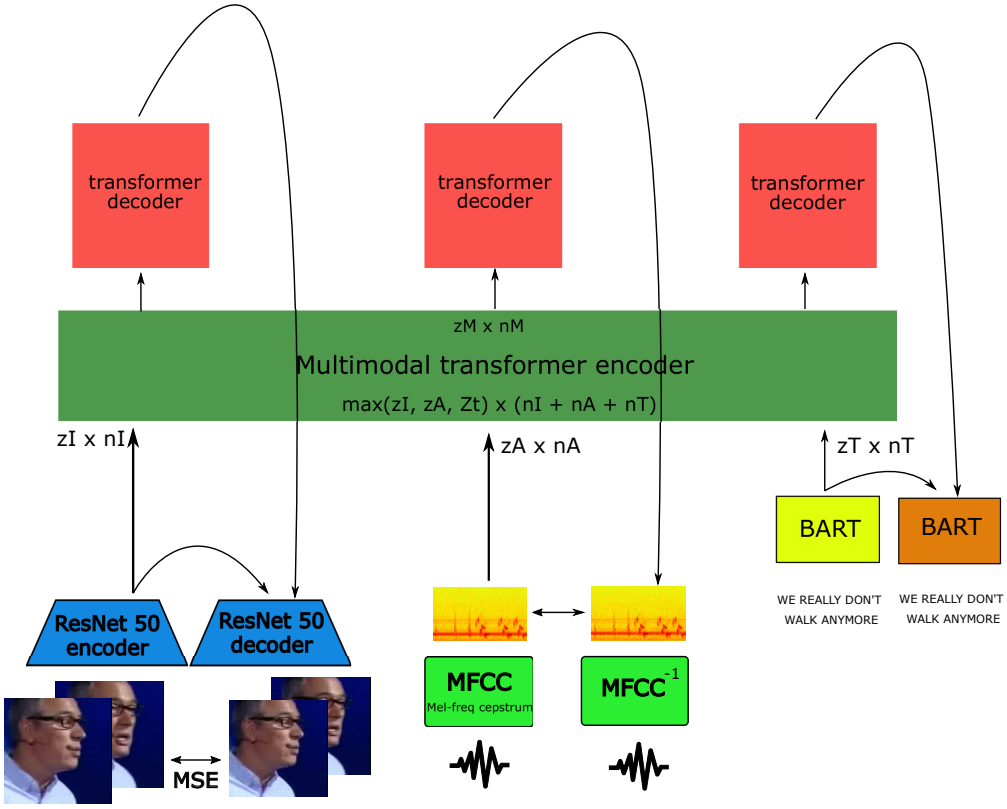

Figure 3: Architecture of Benjamin's model.

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Knowledge extraction and optimization of electronic board production processes

DUONG

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Keywords : Manufacturing, Industry 4.0, Machine learning, Process mining, Optimization

About me...

My name is Le Toan DUONG, 1^{st} year PhD student at LAAS CNRS and Vitesco Technologies company. I graduated in Applied Mathematics from INSA Toulouse, in 2019. My field of study is data science, particularly in the research of new machine learning methods to be applied to real problems in industry. During my academic studies, i did two internships, one for 3 months about the statistic in ecology and the other one for 6 months about images anonymization with Machine learning methods. I am currently researching log-based methods to optimize the electronic board production processes. I am looking forward to sharing experiences exchanging knowledge, ideas and inspiration with you all.

Abstract of the project

The automotive sector requires a high production of electronic boards and demands quality and performance. Today, electronic boards are manufactured continuously 7 days a week, 24 hours a day, which requires the implementation of an optimized process and manufacturing system. However, these are in constant evolution to meet the manufacturing needs of the various products and the needs related to the maintenance of equipment and tools. A detailed understanding of the processes and state of the manufacturing system can only be obtained from an analysis of the logs and specific indicators generated by the equipment. On another note, the state of the system determines its proper functioning and its maintenance contributes to the overall optimization of the process.

The objective of this thesis will be to design and develop a method allowing a multiform analysis of large dimensional flows and available data from several production lines in order to extract knowledge to identify processes (process mining), the state of the manufacturing system and to anticipate weak points and possible future failures to manage process optimization. This method will be based on data mining and unsupervised learning methods as well as model-based diagnostic and prognostic methods. It will be based on the concepts of hybrid AI, combining machine learning algorithms with reasoning models. Thus, the knowledge extracted from the analysis of logs, signals, and indicators will be used to detect anomalies and predict deviations in the process and/or its components.

References

Knowledge compilation for incomplete combinatorial optimization techniques

Tran

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Integrative Program	IP C - Collaborative AI

Keywords : On-the-fly compilation, approximate compilation, local search, conflict-based heuristics, clause learning

About me...

I am now a first-year PhD student at ANITI Toulouse and my host labs are the Institut de Recherche en Informatique de Toulouse (IRIT) & the French Aerospace Labs (ONERA Toulouse). I graduated from INSA Toulouse with an engineering degree (BAC +5) in Computer Sciences in October 2020. My research interests lies on Artificial Intelligence (AI), Machine Learning (ML) and Operations Research (OR), in particular Constraint Programming. I am highly interested in building *hybrid intelligent and trustworthy systems*, which can combine perception, efficient representation, action and learning. My PhD work will focus on the interaction between knowledge compilation and incomplete combinatorial optimization techniques as well as its practical applications to the aerospace field.

Abstract

In combinatorial optimization, the objective is to find an assignment to a set of decision variables that satisfies a set of constraints and that optimizes a given objective function. Incomplete search techniques, such as local search or various kinds of metaheuristics [1] do not offer the guarantee to find an optimal solution, but their main strength is their capacity to find good quality solutions even for large-size instances and even if the computation time is limited. One common difficulty of these techniques is the need to define strategies to escape from local optima and avoid revisiting the same solutions over and over. My PhD topic aims at exploring *Knowledge Compilation* techniques [2], which are a family of approaches handling effectively with intractable problems (beyond NP-hard), for boosting incomplete search algorithms thanks to long term and efficient memory data structures. The idea is to learn conflicting solutions [3] (that violate some constraints or that are sub-optimal) and to exploit them to (i) avoid reconsidering the same solutions and (ii) guide search to the promising space.

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Convex optimization for discret graphical models

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Integrative Program	IA Collaborative

Keywords : Constraint programming, Combinatorial optimization, Graphical models, Convex optimization, Convex relaxation, Low rank methods

About me...

My name is Valentin and I'm currently a first year PhD student at ANITI. I graduated in computer science and applied mathematics from INP-ENSEEIHT, a french engineering school. I also have a master degree in Performance in Software, Media & Scientific Computing. This is my fourth year in the enjoyable city of Toulouse. I spend most of my free time doing sport (Boxe, Rugby). Concerning my research topics, I'm mainly interested in convex optimization and its application to combinatorial problems. During my 6 months internship at INRAE Toulouse, I proposed a convex relaxation for a certain kind of combinatorial problem called WCSP (Weighted Constraint Satisfaction Problem [1]). This particular convex relaxation can be efficiently solved by a new coordinate-descent algorithm called the Mixing Method [2].

Abstract of the project

Graphical models define a family of formalisms and algorithms used in particular for logical and probabilistic reasoning, in fields as varied as image analysis or natural language processing. They can be learned from data, providing probabilistic information that can latter be combined with logical information. The objective of the thesis is to improve the efficiency of algorithmic reasoning on these models in order to increase the power of the fundamental reasoning mechanism used in these tools (lower bound computation) by exploiting the progress made in recent years in the field of convex optimization. This should make it possible to solve problems beyond the reach of our most effective tools.

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Keywords : Mathematics, Machine Learning, Brain-Computer Interfaces

About me...

I had a double training on mathematics and engineering. Specifically I did a master on topology and geometry, and another master in machine learning. I hope to combine what I've learned to reveal more secrets about our brains through analysing the electrical signals that they generate.

Abstract of the project

Brain-Computer Interfaces (BCIs) are devices that allow humans to communicate with machines using only their thoughts. This could be done by collecting various types of brain signals in either invasive or non-invasive ways. I focus on electroencephalography(EEG)-based BCI which is non-invasive and easy to use. EEG signals contain a lot of information about the underlying cognitive process and have very high time resolution, but they have extremely low signal-to-noise ratio (SNR) and are non stationary. The objective of my thesis is to improve algorithms to classify EEG signals for BCI applications so that the classification result is more accurate and robust.

We already did some work using Laplacian computed from the montage of EEG electrodes. We are also working on using topological tools to recognize different brain functional connectivity patterns.

Model Based Reinforcement Learning for legged Robots

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Keywords : Deep Learning, Robotics, Optimization

About me...

I am in the first year of my Ph.D. at the Artificial and Neural Intelligence Toulouse Institute (ANITI). I graduated from the School of Informatics at the University of Edinburgh in 2019, where my master's thesis was about the applications of deep learning in concordance cosmology. My current work involves integrating deep learning methods with numerical optimal control.

Abstract of the project

One of the main problems behind optimal control solvers is its computational cost. The primary advantages of deep learning are its ability to learn policies offline and quickly. However, getting optimal control solvers to work in tandem with deep learning is not trivial. One of the primary challenges lies in mimicking the infinite horizon, by learning the optimal "Value" function [1] at a given state. We modify our Iterative RoadMap Extension and Policy Approximation (IREPA) algorithm [2] to iteratively prolong the horizon and learn the optimal value, thus arriving at an infinite horizon. Our initial results based on simple systems like unicycle, indeed proves that optimal control solvers can be merged with deep learning for better efficiency.

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Automated POMDP model learning and planning to drive Human Robot Interaction

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Keywords : POMDP, Offline Learning, Planning, RL, Representation Learning, Human Robot Interaction

About me...

I am a "son of the Vesuvius". Born and raised in Naples, the most beautiful city in the world. Very proud to be friend of a 11 years old Labrador Retriever. I like exploring the world. My passions include reading psychological and philosophical novels (russian literature <3), photography and chilling with my friends. I also try to stay fit! Less importantly, I got a BSc. in Physics from the University of Naples Federico II and a MSc. in Physics of Complex Systems from Sorbonne Université and the Polytechnic of Turin.

Abstract of the project

I am conducting research about Offline Learning for Planning and Reinforcement Learning [1][2]. Briefly speaking: we want to train autonomous agents to efficiently fulfill a task by leveraging only a *fixed* set of previously collected experiences. This is non-trivial, because the quality and the size of the data set greatly affect the final result. The autonomous agent will possess an uncertain knowledge both of the world dynamics, both of the state of the environment. The goal is to develop an automated pipeline that, given a data set as an input, automatically returns the behavioural policy to follow in that context. In the end we will apply these methods to enhance Human Robot Interaction cooperative tasks taking into account the physiological and mental state of the human operator[3] (e.g. Firefighter Robot)

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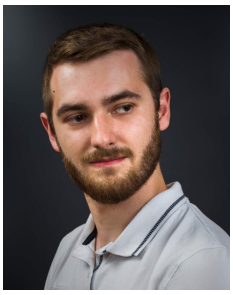

Conception and Learning of decisional and interactive functions for a robot acting as an assistant or a partner

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Keywords : Human-Robot interaction, Decision, Learning

About me...

I'm currently still a M2 student and intern at LAAS-CNRS but soon a PhD student. I will graduate from INP-ENSEEIHT here in Toulouse in late December. It should have been earlier but due to covid my M2 internship has been delayed and thus my graduation. During these three years in engineering school I studied Electrical and Automation engineering and specialized myself in Command, Decision and Informatics of Critical Systems. I also was very active in the school robotic club of which I was vice-president for a year. With the club I participated to the annual "Coupe de France de robotique" two times, this is a very instructive and challenging event. I also participated three times to the "Toulouse Robot Race" which again is very interesting ! About my hobbies, I play the piano, the guitar and even a bit the violin. I like playing competitive multiplayer video games in which you can get better and better over time with training. I love Sci-Fi, Fantasy and Manga/Anime. I was able to spend two months in Japan two years ago and since I enjoyed it very much I hope I can go there again !

Abstract (∼300 words)

The research project is about studying decisional processes required for a cognitive and interactive robot to share decision, task and space with one or several human partners.

The scientific challenge is to design and develop cognitive and interactive capabilities making the robot able to synthesize relevant, clear and readable behaviors for a human partner in the scope of a collaborative activity. Such an architecture should integrate a progressive learning system which shall make the robot able to acquire new collaborative capabilities between itself and the human. Multi-modal dialogue will be considered as a mean to inform the human and assure the consistency of the decisions made by the robot. The system will then be evaluated in different contexts executing joint action and/or learn or even refine collaborative and interactive capabilities with non specialist users.

A constructive approach will be used such as designing an architecture, identifying the collaborative processes and designing a strategy making the robot able to acquire and refine its human collaborative capabilities.

The joint action theory defines the elements which have to be shared to set and handle a joint action. The joint action is "a social interaction in which two or more individuals coordinate their actions in space and time to induce changes in the environment" [Knoblich et al., 2011]. Different coordinative processes required to execute this joint action are considered : self-other distinction, joint attention, understanding of intentional action and shared task representations.

These elements will have to be examined to determinate in the scope of human-robot collaboration if they are relevant, if they are similar between the human and the robot and if there exist others ... Recent works in robotics must be taken into account, especially the notions of goal, plan and shared/joint intention.

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Learning Self- and Semi-Supervised Multi-Modal Representations in Neural Networks

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Keywords : Multi-modality, deep learning

About me

I am a 2nd year PhD student under the supervision of Rufin VanRullen. Prior to my PhD, I graduated from the Supélec engineering school in 2019 where I specialized in Applied Mathematics and Data Science. I also graduated from l'ENS Paris-Saclay MSc: MVA (Mathematics, Vision, Learning).

I then worked on my Master's thesis in the Valeo.ai research group. I studied zero-shot learning in the context of Object Detection and Instance Segmentation.

Abstract

When learning about the world, inputs come in all sorts of ways: images when we look around, text describing objects and their properties, audio during conversations, etc. Most of these inputs are not annotated, and come together asynchronously to build a joint representation of the external world.

Yet, state-of-the-art machine learning models still process inputs largely independently, and heavily rely on the availability of annotated data. While unlabeled datasets are readily available in all shapes and forms (image, video, sound, text, etc.), the amount of labeled data is often scarce, especially for multi-modal data.

To this end, we put our focus on a tri-modal data. In particular vision, audio and text. These modalities and readily available by using videos with transcripts.

For this, we took inspiration in the transformer-based multi-modal literature (for example ViLBERT [1]) which can operate on sequences.

The core of our research is how to merge sequence modalities and obtain a sequential multi-modal representation of all the domains. Our future direction with this project is to include an additional prior on the multi-modal representation coming from a task (different tasks require different domain fusion) or attention.

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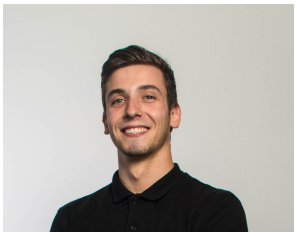

Multiple target extraction, identification and tracking for automotive radar with AI

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Keywords : Radar, signal/image processing, classification, detection, tracking

About me...

Graduated from Bordeaux INP - ENSEIRB-MATMECA as a telecommunications engineer, I started a PhD as part of ANITI about "Multiple target extraction, identification and tracking for automotive radar with AI" in collaboration with NXP Semiconductors.
Before starting my PhD, I studied telecommunications engineering. This included signal and image processing, computer science, networks and digital and wireless communications. Convinced that AI is first of all a tool that can be applied to several field (particularly the ones I studied as part of the telecommunications course), I chose to specialize myself in AI during the last year.
Interested in the automotive sector and in the car of the future, I'm very enthusiastic to work in the next 3 years on algorithms that could lead to safer roads.
My areas of interest are computer vision, pattern recognition, radar and signal/image processing.

Abstract

Today we see the rise of connected vehicles and drones, in the quest for safer, greener and more automated transportation systems. They heavily rely on ADAS (Advanced Driver Assistance Systems), and sense their environment via a large number of different sensors (short-range or long-range radars, camera, lidar, V2X...) to create 360-degrees safety type of cocoon around the vehicle.
The breakthrough in deep learning enable AI systems to successfully identify objects and perform semantic segmentation on live camera images (YOLO, Mask R-CNN...). However, there has been little use of AI on radar data so fat. Contrary to cameras, radar brings complementary information. In particular, radar is able to operate in harsh weather conditions (night, snow, fog, dust, strong light...). However, actual radar modules still output a relatively low content of information regarding the detected targets: only position, speed, probability and some notion of radar cross section are output. Unlike camera images, radar data need strong pre-processing before being used in ML or AI frameworks.
The aim of this PhD is to build new machine/deep learning frameworks specifically tailored to radar data, that will be incorporated in real automotive systems. Those algorithms are expected to detect, identify and track surrounding objects in complex environments. In addition, the following fundamental questions will be address:

- From which representation (e.g., range-speed,micro-doppler,bird view) are the targets identifiable? What are the invariance for those representations?
- What is the amount of pre-processing needed to make deep learning systems fully efficient on radar data?
- Which part of the pre-processing can be replaced in a more efficient or more effective way (with better result) by deep learning systems?

Memory-based Model Predictive Control for Biped Locomotion

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Keywords : Robotics, Optimal Control

About me...

I am an engineering student who has graduated from Ecole polytechnique (Palaiseau) and ISAE-SUPAERO (Toulouse). I am specialized in electrical engineering, control engineering and automatics, with a strong interest in aerospace systems and space science.

Abstract

Model predictive control (MPC) [1] has become a widely used tool in the robotics community because of its ability to handle non-linearity, constraints and system dynamics [2]. Several challenges have to be tackled in order to use a whole-body MPC directly as a locomotion controller for a whole body robot. An efficient numerical optimal control algorithm able to work at high frequency is required, as well as a strategy to tackle non-convexity and overcome local minima problems.

Using reinforcement learning to provide good warm-starts to the MPC solver is a promising heuristic to approximate the optimal behavior of the robot [3] [4]. The idea consists in building a memory of motions by computing a database of optimal trajectories in the context of locomotion, then using it to initialize the solver in a convergent basin in order to reduce online time computation and to better find global minima. This will allow the MPC to be connected as low as possible with respect to the control scheme of the robot, implying a very good adaptive behavior able to reject external perturbations.

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Knowledge compilation for dynamic scheduling

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Keywords: Knowledge compilation, Scheduling problems

About me…

I graduated in 2018 from INSA Toulouse with an engineer degree in Computer science and Networks. After working some time as an engineer, I decided to go back to studying and was selected for the very interesting project I'm working on.

Abstract (~300 words)

Looking for a solution to a scheduling problem under specific constraints is often times very difficult (NP-HARD), and therefore cannot be computed online; The usual approach is to compute in advance a schedule, but that is unsatisfactory, firstly, because a user might want to modify the schedule based on experience or preferences, and secondly because in an uncertain environment, unexpected events such as tasks taking up more time than anticipated or unavailable resources might necessitate to recompute a schedule, which is not possible due to the complex nature of the problem.
This project aims to apply the principles of pre-computing/pre-solving of problems as is done in the Knowledge Compilation field of research, to scheduling problems. The method consists in computing beforehand not a single detailed schedule, but a more flexible solution constituted of a set of different solutions that can be used to face uncertainty.

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Keywords : Deep Learning, Optimization, Dynamical systems

About me...

I'm a French student originating from ESSEC and Ecole CentraleSupelec where a studied Applied Mathematics and Statistics. My research thesis was on distributed continuous optimization applied to Majoration-Minimization algorithms. My current work deals with an the interpretation of deep learning models as dynamical systems.

Abstract of the project

The perspective of artificial neural modules as mathematical functions describing a vector field over a topological activity space opens interesting perspectives for deep learning: This view interprets the sequential computation of stacked or recurrent neural modules in traditional deep neural networks as the discrete evolution of a dynamical system, such that a particular parametrization of the module gives rise to particular trajectories of hidden state/activity tensor given their initial point (input stimuli). Recently, new approaches have developed further this view suggesting to solve the ordinary differential equation (Neural ODE) associated with the said module function, such that model depth corresponds to integration over time. This interpretation culminates in the assimilation of neural networks as particular flows. Despite their elegant formulation and lightweight memory cost, neural ordinary differential equations (NODEs) suffer from known representational limitations. In particular, the single flow learned by NODEs cannot express all homeomorphisms from a given data space to itself, and their static weight parametrization restricts the type of functions they can learn compared to discrete architectures with layer-dependent weights. [1, 2, 3]

References

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Pseudo Boolean Learning for reasoning on graphic models

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Keywords : Optimization, Weighted Constraint Satisfaction Problem, Learning, Pseudo-boolean constraints

About me...

I'm freshly graduated from the engineering school Polytech Clermont ferrand with specialty mathematics and modeling, I also obtained a master's degree in Computer Science at the university of Clermont-Auvergne. I oriented myself toward research after two rewarding internships, one in 2019 at Kumamoto University, and one earlier this year at INRAE. In the first one, under the supervision of CHIBA Shuya and in collaboration with a Japanese student MISHIO Eishi we manage to prove a theorem in graph theory. Basically if a directed graph is sufficiently large and connected we proved the existence of a particular spanning subdigraph (a directed path-factor), you can find more information on the paper we published after the internship [1]. The second internship I did was with Simon DE GIVRY and George Katsirelos (my actual PhD supervisors) at INRAE, the goal was to improve Toulbar2, an optimizer for cost function networks and discrete additive graphical models. I had to propose an algorithm well suited to Toulbar2 to cope more efficiently with linear constraints. I then implemented it to Toulbar2 and launch some benchmarks to verify it's efficiently, we noticed some nice improvement on some kind of problems. We are pushing further this result in my PhD. Here is the source code of Toulbar2 : https://github.com/toulbar2/toulbar2.

Abstract (∼300 words)

Graphic models are information representation tools capable of supporting both logical and probabilistic information. They therefore lend themselves well to the treatment of problems requiring the integration of data (learning), by estimating a probabilistic graphic model from data (via the classical principles of penalized maximum likelihood or maximum margin) and logical properties (constraints).
In the specific case of problems representing only logical information, a simple but extremely effective mechanism called "conflict-directed learning" [2] is used by many of the most effective proofs (SAT solvers, CSP). Starting from a conflict observed during a tree search, they are able to produce information (constraint) that is a logical consequence (a relaxation) of the whole problem, which can then be exploited to facilitate the resolution of the original problem.
The aim of the thesis is to generalize this learning mechanism in the case where numerical information possibly estimated from data (such as probability/energy or cost) is available in addition to logical information.
If we want an effective algorithm we need to be particularly attentive to the following points :

1. it is necessary to define precisely the mechanism to learn pseudo-Boolean constraints in conflict situations, in particular by selecting an optimal (but probably heuristic) way to choose the best pseudo-Boolean constraint(s) to keep.

2. this mechanism should ideally be able to work with the different types of local coherence used so far in graphical models [3], both simple local coherence (arc coherence, bounded max-resolution) but also, in the longer term and in principle at least, on algorithms running on so-called global (or higher order) functions.

3. efficient mechanisms for taking into account the information generated during the resolution, to speed up research. This is quite immediate in the case of logical proofs, because the logical consequences can be immediately added to the problem to be solved. The numerical case is significantly more difficult, because the information learned is not of the same nature as the information present in the graphical model.

4. a mechanism for selecting the most relevant learned information, which is kept over time or, on the contrary, forgotten. Indeed, producing an excessive amount of information learned from conflicts can ultimately have a counter-productive effect, slowing down the search.

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