SophI.A Summit 2021

Abstracts of contributed papers, posters and demos

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AI and health

3D enhanced fall detection based on keypoints extraction from OpenPose

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The fall of an elderly people can have fatal consequences on their health. The sooner the person is taken care of, the greater his chances of a good recovery are. Fall detection is a major problem that is being studied by the scientific community. There are many types of fall detection system such as wearable devices (connected watch, necklace) or ambient sensors (vision systems, motion detector, pressure-sensing rug). Vision sensors have the advantage of being totally autonomous from the final user, not expensive for most of them and easily maintainable. Combining deep learning techniques with deterministic rules allow to efficiently leverage the analytical capabilities of neural networks.

The core of our work is to detect the characteristics of falls (event and state) based on the analysis of skeletons information, extracted from images through OpenPose, an IA body landmark detection algorithm. After extracting keypoints, we compute and analyse metrics as body speed, keypoints position, body angle with the ground through frames sequences. It is their aggregated values as a "fall probability score" that verify the state of fall. The main challenge of our workflow is to ensure and maximize the quality of the data that feeds our rule-based system. We have encountered some bad or missing keypoints predictions from OpenPose, and faced that our algorithm, is not well able to detect falls which occurs in the depth of the camera field. To tackle those issues, we have experimented and integrated algorithms able to predict missing points, as the Lucas-Kanade optical flow method, and DeepLabCut, a neural network able to track and label landmarks. Extend our work to 3D analysis also allow us to catch more information about the scene and the orientation of the body. Moreover, 3D data from triangularization techniques ensure our system to be more robust to occlusions.

We experimented our algorithm over a dataset called "Multiple cameras fall data set" created by the University of Montreal. The dataset contains 24 indoors scenes monitored by 8 2d-cameras, meaning 192 videos. Each scene contains multiple actions and falls. The total number of falls is 207. We reached 73% of accuracy, with 66% of recall from our first experiment over 2d flows. Among the remaining undetected falls, half are due to keypoints detection lose, the other half due to depth falls, which is hard to catch for our 2d rules-based system. From those experiments, we are now testing a 3D approach, by triangulating multiple 2D views of body-keypoints. This way we attempt to prevent lack of keypoint detection and be able to catch more falls. First 3D experimentations give us 25% of improvement from previous results. Although, more tests must be realized to confirm those results.

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To conclude, first results tend to confirm the relevance of tackling the fall detection with a deterministic system strengthened by AI technology.

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Keywords: Fall detection, Skeleton keypoints extraction, Healthcare system, Video surveillance, 2D/3D sensors, OpenPose

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Mixing IA and deterministic methods for the design of a transfer system for frail people
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A transfer system is an apparatus that allows frail people to regain some mobility (e.g. being able to move
from a sitting position to a standing one without external help). Such a system must be totally safe, should have
a low intrusivity and must be able to lift a large load. The solution we propose is to use a cable-driven parallel
robot (CDPR). In such a system a platform is connected to the ground through 4 cables whose lengths can be
modified by 4 winches located close to the ceiling at the four corners of the room. The 4 cables are attached
at the same point of a platform which will be the moving part of the CDPR. By modifying the lengths of the
cables it is possible to move at will the platform in any direction. Handles on the platform can be grasped by
the frail people or they can connect a medical harness to the platform. Note that by instrumenting the platform
it is possible to perform walking analysis and thereby assess the frailty level. To design a CDPR it is necessary
to determine key indicators (KI) such as the maximal cable tensions when the users moves in the room that will
allow to determine the necessary cable strength and diameter, the motor maximal torque and velocity, . . . To
determine the KI it is compulsory to solve the kinematics of the CDPR namely the inverse kinematics (finding
the cable lengths for having the platform in a given position) and the direct kinematics (finding the platform
position for given cable lengths). Solving the kinematics amounts usually to solve a large square system of
equations and if a realistic cable model is used (that takes into account the cable elasticity and the influence
of its own mass) there is no known analytic solution to the kinematics. Furthermore the solving must be exact

*Speaker

as most of the KI are safety critical. Various numerical schemes have been proposed for that purpose but they
are computer intensive while in the design process kinematics will have to be solved a large number of time.
A major issue is that most of the kinematics problems have usually several solutions [1] and it is necessary to
determine them all to ensure that the KIs are determined even in the worst case.
We have experimented using neural networks for solving the kinematics of CDPR. Neural networks have
been proposed for parallel robots having rigid extensible legs [2, 3] with mixed results and more recently for
CDPR [4] but numerous issues are still unsolved.
As we have alternate solving methods it is relatively easy to build a large training set with exact result
and a verification set that allows one to exactly quantify the quality of the result. A systematic search with
various number of layers and various activation functions has allowed us to determine that neural networks are
not accurate enough for our design problem. But we have also shown that mixing several neural networks and
deterministic methods such as the Newton scheme allows one to get exact result in a low computation time. We
will also show that we may use the result of the proposed method as a starting point for managing the unavoidable
model uncertainties with interval analysis, thereby providing a safe background for the design.
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July, 7-9, 2021.

Keywords: transfer robot, design, frailty assesment, kinematics

Multiples inputs neural nets for Medicare fraud detection

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Medicare fraud results in considerable losses for governments and insurance companies and results in higher premiums from clients. According to Insurance Europe, detected and undetected fraud costs around 13 billion euros per year to European citizens. In the field of healthcare insurance, in France the compulsory scheme detected over 261.2 million euros of fraudulent services in 2018, mainly due to healthcare professionals and healthcare establishments. In the United States, according to the FBI, medicare fraud costs insurance companies between 21 billion and 71 billion US dollars per year. In a context where reducing management costs is a real issue for healthcare insurers, the fight against fraud is a real expectation of the customers of professionals in the sector so that everyone receives a fair return for their contributions.
This study aims to use artificial neural network based learners to detect fraudulent activities in medicare. We tested several neural network architectures and compared them to some baseline machine learning classifiers (logistic regression, random forests, Gradient boosting) based on the ROC AUC metric. We have used two types of neural network architectures: single input layer neural network models and multiple input models. We use the Medicare Provider Utilization and Payment Data from the Centers for Medicaid and Medicare Services (CMS) of the US federal government. The CMS provides publicly available data that brings together all of the cost price requests sent by American hospitals to health insurance companies. The CMS data we use in this study has two parts : Part B that contains information on utilization, payment (allowed amount and Medicare payment) and Part D that provides information on prescription drugs prescribed by individual physicians and other health care providers. The main difficulty in applying machine learning methods in fraud detection is that the data sets are imbalanced and the classifiers tend to favor the majority class. The CMS data is particularly highly imbalanced with fraud rates between 0.038% and 0.074%. The constructed classifiers should thus be able to take into account this issue of imbalance and give more importance to the minority class which is often the class of interest.

We first merged the two data sets and used it as input to a baseline multilayer perceptrons (MLP) neural network. In this architecture, all the features are used without making any distinction between them to predict fraudulent activities. Secondly, we separated the data set in two parts: Part 1 contains all features related to the provider and Part 2 contains the features related to the claim it self. We then used a MLP neural network with two distinct input layers, the first input layer takes Part 1 as input vector and the second input layer takes Part 2 as input. The final model is thus composed of two blocks which meet. Each block has its own input

*Speaker

layer, hidden layers and an output layer. The outputs of the two blocks are then concatenated to form a single vector used to predict the probability of fraud. Such an architecture makes it possible to simultaneously take into account the information on the claims and that on the provider without mixing them. The second block in this architecture can be a classical MLP or an auto encoder. When it's an auto encoder, we pretrain the auto encoder separately and use its weights in the final model in the form of transfer learning.

Our results show that although baseline MLP neural network (AUC=0.859) outperform the baseline machine learning classifiers (logistic regression = 0.849, random forests =0.769, Gradient boosting =0.692), they are outperformed by the multiple inputs neural networks with auto encoder (AUC=0.876). We have shown in this study that artificial neural networks based learners make it possible to detect fraudulent activities in medicare and in addition that multiple inputs learners give better results.

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Keywords: Medicare, fraud detection, machine learning, neural networks, imbalanced data

Prediction of severe COVID-19 among in-patients using lab results and comorbidities: a retrospective and observational study

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This submission concerns an ongoing work which is to be published by the end of 2021.

Background

Since the identification of the first cases of COVID-19 in Wuhan in December 2019, more than 180 millions of cases have been reported worldwide. Although the majority of patients experience asymptomatic or mild infections, others develop a severe form with complications including acute respiratory distress syndrome, septic shock, thromboembolism, and multiorgan failure. To this day, COVID-19 has caused more than 4 million deaths worldwide, and hospitals and intensive care units (ICU) have been overwhelmed by COVID-19 patients, hence the critical need of identifying patients at risk of developing a severe form.

Objective

In partnership with AP-HM (the third largest hospital system in France), Kiro designed an algorithm to predict up to three weeks ahead the evolution to a severe COVID-19 for in-patients diagnosed with COVID-19. This may lead to a decrease in costs and load, and also to a reduction in sequelae for the patient.

Materials

This is a retrospective study based on observational data from AP-HM from January 2020 to April 2021, hence covering the apparition and spread of variants and the beginning of the vaccination. 18.697 patients were included in the study.

*Speaker

Methods

The considered variables for prediction were age, sex, lab results results and comorbidities. As the practitioner's prescription pattern is strongly correlated with the patient's condition, imputation techniques and variable selection were used to ensure that the study focuses on the in-patients biological profiles.

Severe COVID-19 is defined by the occurrence of the patient's death or the patient's admission to an ICU.

Models were trained using different subsets of variables to determine their contribution towards the prediction of severe COVID-19. Each training occurred on patients diagnosed from January to November 2020, while the validation and testing sets respectively covered December 2020 to January 2021 and February 2021 to Mars 2021. This strategy ensures that the results of this study are robust to changes of standards of care, variants apparition (mainly the Alpha variant) and evolution of the in-patients population, including the vaccination.

Thresholds were determined on the validation set and final metrics were computed on the training set.

Results

Computed metrics were an AUC of 0.892, a precision of 38%, a sensitivity of 67% and a specificity of 91%, which are higher to the state of the art.

Results regarding the most important predictors are consistent with existing studies and knowledge about the disease, while this study emphasizes that in-patients biological profiles are more informative than their comorbidities.

Conclusion

Lab results data is a fast, cheap and non-invasive source of information, which justifies its always growing and universal use. Besides, it is also extremely accurate. This study highlights its importance and displays one of its more modern and effective use cases.

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Keywords: Machine Learning, COVID, 19, disease prediction, clinical biology, risk factors, personalized medicine

Probabilistic SIR-Epidemics and Control Scenarios on Artificial Social-Connection Networks.

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A probabilistic approach to epidemic evolution on realistic social-connection graphs allows for characteristic differences among subjects, including the individual structure and number of social contacts ('ego networks') and the individual infection and recovery rates according to age or medical preconditions. Within our probabilistic Susceptible-Infectious-Removed (SIR) model on graphs, we compare the infection load and proxy cost of control scenarios by confinement, vaccination, and their combinations. The epidemic diffusion is explored on random social-connection graphs designed for more realistic person-person characteristics.

The COVID-19 pandemic has stimulated a novel interest in models of epidemics (Bertozzi et al 2020). Epidemiological models have guided governmental and policy makers to develop policies including social distancing, economic lock downs, vaccination campaigns while controlling the risk of new waves of infection. Starting with Kermack and McKendrick (1927), several models have been elaborated which subdivide a population into designated compartments in which individuals are allocated by their disease status (Hethcote 2000, Choisy 2007). The classical Susceptible-Infected-Removed (SIR) model is part of the basic compartmental epidemic approaches. In this model individuals are allocated either to 'susceptible' (S), 'infected' (I), or 'removed' (R) meta-population. The extensions of simple epidemic models for populations towards structured networks of individual agents (or meta-populations) (Barabasi 2013, Newman 2018), have successfully been employed in many fields to study phenomena for which interrelationships matter (Perc 2021) and, include, biological demographic dynamics (Montagnon 2019), international trade (Banerjee 2013), technology diffusion (Eaton 1999), information spreading (Liu and Zhang 2014, Li et al 2017), and contagion in financial markets (Demiris et al 2012). In our present study we explore an extension of the SIR model and control scenarios on social contact networks. The adoption of a network-based approach to modeling an epidemic allows the description of patterns of interaction among individuals - the variety of ego network - or households. The network links describe the person-person interactions that potentially spread the contagious disease. The standard SIR approach models the evolution of an epidemic within a given population, based on a simple interaction assumption and population split into three different compartments. In our present development of a SIR epidemic on a graph we explore control scenarios that influence the progression of the epidemic at the individual level, rather than by compartments or e.g. age related meta-groups of the population as in recent work by Nakamura et al (2021). This more detailed dynamic approach can take into account the socio-spatial distribution of individuals and the differences of infection and recovery capacities in each

*Speaker

individual. Such approaches with socio-spatial structure of the population by using complex graph topologies have been successfully developed in various domains (Keeling 2005, Zhou 2006, Newman 2002, Ganesh et al 2005, Lu et al 2017).

In particular, our approach aims to describe the epidemic dynamics immediately at the level of the individual's intrinsic susceptibility, infection and recovery probability, similar to probabilistic Markov or quantum-like system descriptions, e.g. (Busemeyer and Bruza 2012, Wang et al 2013, Broekaert et al 2020, Wang et al 2003). The probabilistic interpretation of the graph state vectors of the nodes allows the expression of any SIR-related expectation quantity on any targeted subset of nodes.
We implemented random contact network architectures - with realistic aspects of person-person networks (Barrett et al. 2009) - for the diffusion and control scenarios of artificial epidemics, and compared the 'infection load' of an epidemic - as a proxy for the economic cost - for the 'no-control' scenario, a confinement scenario, a vaccination scenario, and a combined vaccination-confinement scenario. Confirming expectations the earliest starting time point of interventions results in the lowest infection load over the social contact graph. Also in line with expectations, the combination of the scenarios of vaccination and confinement of the population in the social contact graph results in the lowest infection load, albeit at the summed total cost of both separate interventions.

Keywords: SIR dynamics, social graph, confinement, vaccination

Swarm learning for extremely distributed and privacy-preserving ML-based analytics in healthcare and life science

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In the actual fast-paced increasing in connected end-user and outlet devices, the organizations are under the pressure to deliver value through data-insight-driven solutions. However, the explosion in generation of new data brings the approach to their analysis to a new level and requires innovative system architectures. A paradox in the current data eco-systems is that data is mostly generated at the edge, while its transformation to information is performed on centralized systems, whether they are on-premises or in the cloud. This has a huge impact on network infrastructures and its relative costs of use, produces serious incompatibilities in various realtime use cases, often clashes with national privacy and confidentiality regulations, and limits enduser experience. Data needs to be able to be processed and analysed on spot, namely at the edge. Conceptually, this is possible if sufficient storage and computational infrastructures are available locally, so that machine learning (ML) can be totally carried out "at the edge", namely from model training to inference. However, having highly accurate AI-based solutions also requires appropriate algorithms and large datasets for model training purposes.
In those scenarios intrinsically decentralized (e.g.: medicine, bioscience, urban mobility), where the volume of data available locally is often insufficient to train reliable AI models, an approach to AI based on data centralization has long been favored, which nevertheless suffers from the problems illustrated above. Federated AI (FAI), leveraging on star-shaped architectures, has been introduced to address some of such limits [1]. While data are kept locally (at the edge) and privacy issues are addressed [2], the model parameters in FAI are still handled by central custodians (dedicated servers) which as the intermediaries concentrate power of the learning to themselves and are responsible for aggregating and distributing local learning.

The demand for alternative to FAI, which can dispense with centralized elements and functions, is answered by Swarm Learning approach [3,4] (SL). SL is a decentralized ML approach uniting edge computing, blockchain-based peer-to-peer networking and coordination as well as privacy protection without the need for a central coordinator. Practically, SL is a framework designed to make it possible for a set of nodes – each node possessing some training data locally – to train a common ML model collaboratively without sharing their specific training data sets one each other. This can be achieved by individual nodes sharing parameters (weights) derived from training the model on the local data, rather than sharing local data themselves. The fact that data are not exchanged among the nodes allows to maintain the privacy of the raw

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data. Parameters obtained from all the nodes are then shared and merged to obtain a global model. Moreover, the merge process is not done by a static central coordinator or parameter server, but rather by a temporary leader dynamically chosen among the peer nodes, thereby making the Swarm network decentralized and fault-tolerant. This provides a far greater fault-tolerance than traditional centralized-parameter-server-based frameworks. The integration of SL framework with the blockchain technology extends the applicability of SL to international and multi-organization contexts even subjected to different privacy legislations. The extreme modernity of the underlying architecture of the SL framework comes from the distribution of the data platform and related compute power on multiple nodes, with heterogeneous characteristics, and dispersed at the edge.
As first use cases, SL was successfully applied for predicting leukaemia, identifying tuberculosis and COVID-19. During this presentation, we illustrate the operating principles of the SL framework and a high-level technical description of the nodes, and describe the results of the application of SL to the clinical cases above

Keywords: Swarm Learning, Decentralized Machine Learning, Privacy preserving Machine Learning, Precise medicine, Federate AI

Unsupervised Adverse Drug Event related document detection with Bert-based model

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Detecting adverse drug events (ADEs) in the medical reports plays an pivot role in pharmacovigilance. However, to identify and report important ADEs relies on well-trained health professionals, which limits the efficiency to detect ADEs and also causes heavy-loaded work due to the relatively small population of well-trained professionals and rapidly increasing number of reports every year. Another fact is that annotating data is expensive and will also add workload to them. We want to propose an unsupervised approach to distinguish the reports with and without ADEs descriptions.

We made the hypothesis that for any ADE, both the drug and the adverse effect are described within the same block of textual content. We defined henceforth "block" as the basic unit of textual content to analyse, which can be either whole document, paragraph, sentence, etc. Then the problem becomes: For a given set of blocks, suppose that we have had in advance the knowledge for the drug entities and symptom entities within each blocks (since drugs must have marketing authorisation and medical descriptions of symptoms have their universal codification), we want to separate the blocks with the description of ADE (noted as positive block) from those who don't (noted as negative block). For the moment we chose "sentence" as the "block" of textual content and consider for now the intra-sentence information, and used all sentences that contains exactly one drug and one symptom (since in unsupervised system, we have no idea in advance that whether the symptom is adverse effect of the drug or the cause of taking the drug or even an irrelevant symptom) by the help of entity type information for drugs and symptoms in MADE[2] data. Then we represent the sentence by the content windows[1] around entities and feed them to transformers model to encode each sentence into vectors of the same size. Finally A clustering algorithm is used for creating clusters of similar sentences. The ideal practice is to obtain a cluster with only positive blocks and another with only negative ones.

We studied the performance of two Bert-based model, SBert, who is able to "derive semantically meaningful sentence embedding"[4], and BioBERT, a domain-specific transformer which is pretrained on biomedical corpora[3]. We chose also a fully supervised approach (Bag of Words + Logistic Regression Classifier) as the baseline. Comparing to the supervised approach, the SBert embedding + clustering strategy could achieve similar precision (0.726 vs 0.713 for BOW+LR) but the SBert-based approach has lower recall value (0.493 vs 0.760 for supervised approach), which leads to a lower F1-score (0.587 vs 0.736 for supervised baseline). On the other side, by applying mean pooling for the output of BioBert as embedding for sentences, this approach

*Speaker

has a little lower precision score (0.648) comparing to the SBert one, it has however a higher recall score (0.760) and thus has better F1-score as 0.699. This is because the domain specific dictionary the BioBert while that of SBert is still more general.

Keywords: Adverse Drug Event, Natural Language Processing, Electronic Health Records, Unsupervised Learning, Transformer, based Model, Deep learning

Sustainable AI

A COMPUTER VISION APPROACH FOR DISEASE DETECTION IN PLANTS THROUGH MACHINE LEARNING AND DEEP LEARNING

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Plant growth monitoring and plant protection are key elements in the agriculture industry. Due to weather and seasonal conditions,
crops are exposed to diseases, which can incur losses if not detected in time. These diseases aect the leaves of the plant
and later can infect the whole plant, which in turn aect the quality and quantity of crop cultivated. As there are large number of
plants in a farm, it becomes very dicult for the human eye to detect and classify the disease of each plant in the field. Over the
last few years, computer vision techniques, machine learning algorithms, and deep learning models have become more prominent
due to their capability of dealing with complex data with precision. These techniques are well known for pattern recognition and
classification problems. In this paper, we are introducing an automatic plant disease classification using artificial intelligence in
order to detect precisely only the aected plants to carry out precise spraying of pesticides. Using a dataset of 11 classes of 300
images per class,our methodology successfully classifies plant diseases with an accuracy of 86% when processed by Random Forest
classifier and an accuracy of 98.28% when processed by convolutional neural network.

Keywords: Computer vision, Convolutional neural network, Deep learning, Machine Learning, Image classification, Plant pathology.

*Speaker

Beyond algorithmic transparency: from explainable AI to social acceptability

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Submission for a talk
Sustainable AI

"Beyond algorithmic transparency: from explainable AI to social acceptability"

This proposal aims to explore the concept of "sustainable AI", through a multidisciplinary dialogue between social sciences and algorithmic ones. This talk will take the form of a cross-discussion between lawyers, economists, and experts in AI and computing sciences. The purpose of this discussion is to go beyond transparency to think about what sustainable AI should be. More precisely, the move towards a sustainable AI depends on the social acceptability of algorithms. We will try to answer this question: how to get citizens to contribute to the development of algorithms for public goods?

Therefore, the expert panel will examine the meaning and content of the notion of social acceptance of algorithms, highlighting their respective areas of expertise.

The project submitted for the SophIA Summit is part of the Sustainable AI theme and aims to build the principles of regulation of AI systems, in order to better understand and identify the objective of "sustainable AI". More specifically, we believe that sustainable AI must address two important issues:

*Speaker

-the accountability of AI systems

-and their control.

Indeed, artificial intelligence systems, as well as the technologies that make them possible, have raised concerns and criticisms relayed in the public and political spheres. These criticisms target in particular algorithmic biases, the opacity of the algorithms deployed by large companies, the implementation of some technological tools without prior public consultation (as facial recognition, pandemic monitoring application, etc.) or even the absence of a clear legal and regulatory framework to set out responsibilities and requirements for AI systems. A social mistrust toward artificial intelligence might result from these trends and then require to design and promote a sustainable artificial intelligence.

Thus, it seems crucial to define what have to be the principles required for socially acceptable AI systems, to ensure their social acceptability. Indeed, the deployment of these systems and the success of their development, both at the technological and industrial point of views, will depend on the support of all members of society : users, consumers, and citizens.

Our project proposal is a submission for a talk by four speakers:

- an artificial intelligence specialist (**Hughes Bersini**, Professor at Université Libre de Bruxelles and Co-Director of the IRIDIA laboratory)

- a computer scientist (**Benoit Rottembourg**, INRIA, Paris)

- an economic expert (**Frédéric Marty**, CNRS France)

- and a professor of law (**Marina Teller,** UCA, 3IA Côte d'Azur Chairholder).

The roundtable will analyze and tackle the scope of "sustainable AI", in its triple component:

- With regard to regulations, with a focus on compliance by design, transparency and explainability

- With regard to the ecological constraint

- With regard to social acceptability.

The presentations will highlight the issues related to the responsibility and control of AI and will be based on concrete cases (the use of pricing algorithms; tracking devices used to fight against the pandemic).

Prof. Bersini will explain his **CITICOD project** that is carried out in Brussels. This project is an attempt to build a new type of algorithmic governance : this project aims to establish a solid protocol for the citizen participation in the writing of computer codes and in the definition of the design of software that intervene in the implementation of public policies.

Keywords: Sustainable development, social acceptability, algorithmic audit, legal framework for algorithmic processes, principle of contestability

Communication-efficient Federated Learningthrough clustering optimization

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We study the problem of model personalization in Federated Learning (FL) with non-IID (Independent and Identically Distributed) data collected at nodes in a network, under the network communication cost constraints. Classical FL collaboratively trains a unique global model. If data is statistically heterogenic (non-IID), personalized models for groups of nodes with similar statistics have been shown to provide better performances compared to FL [1].
We propose a Clustered Federated Learning approach that provides a trade-off between identifying models that are more adapted to nodes locally, under communication cost constraints. Our method identifies clusters of nodes with similar data statistics, which improves the local model accuracy. In particular, it aims at finding the cluster structure, cluster heads and a set of model weights (one per cluster) that minimize an objective function composed of two terms: a classical multi-task optimization term and a communication cost regularization. Local model updates represent proxy values of the local data distributions (statistically similar train sets have similar updates) where similar updates are aggregated together [2,3,4].

Our algorithm has two phases: initialization and cluster optimization. During the initialization, nodes collaboratively train a global initial model. The cluster head nodes are identified and nodes are clustered based only on the communication cost minimization [5]. The cluster optimization phase starts by applying the Hierarchical Agglomerative Clustering on a distance metric composed of two terms: the cosine dissimilarity between the locally computed model updates of two nodes, and the communication cost of grouping two nodes in the same cluster. In parallel, respective cluster heads are also optimized. The clusters are organized in a tree hierarchy. At each round, the cluster heads verify if a new cluster optimization is needed based on the model update values. If required, the same method is applied to further create sub-clusters. We evaluate our method on several non-IID settings generated from MNIST dataset, while simulating the communication cost at each round. We show that our algorithm improves the quantity of nodes reaching 99% of accuracy (from 48% to 72%) and can reduce the overall communication cost by 35%. Finally, it is able to adapt the cluster structure in case of new conditions (new

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network nodes or time-evolution of local data distribution) by a tree structure search.

Keywords: Federated Learning, Model Personalization in Federated Learning, Clustering, Communication, efficient optimization

Teaching Python and the basics of Machine Learning to High School students

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Teaching AI at school is of paramount importance. As part of Orange CSR activities and my secondment as "Ingénieur pour l'école" at the Nice Academy, I designed a workshop to teach Python and the basics of Machine Learning to two freshman year classes (9th grade) from two High Schools around Sophia Antipolis.
This work was done within the framework of the "Arc-en-ciel" project of the " Maison de l'Intelligence Artificielle " (AI House) of Sophia Antipolis (https://www.maison-intelligence-artificielle.com/), of which I lead the pedagogical team.

Since 2019, Python is part of the National Education program of the sophomore year (10th grade) of High School, while Middle School students concentrate on block programming with Scratch (6th grade).

This experiment aims at building continuity between block programming and a programming language as Python, using Machine Learning libraries. In the French Educational System, 6th grade is the last year of the "collège" (Middle School), while 10th grade is the first year of the "Lycée" (High School). Hence the workshop bridges the work done on Scratch during the 6th grade and later years of the "collège" with what will come in the 1st year of the Lycée.

The workshop starts with the " Teaching Machine (TM) " AI extension of mBlock (Scratch alternative) and ends with the IRIS dataset of the Scikit-Learn Python library. Adding an extension to mBlock is similar to importing a library in Python and both demonstrate to students Machine Learning algorithms like a Gaussian classifier. The Python language section has been adapted from the 1st chapters of an "Open Classroom" online course, enabling interested students to explore more of the language on their own.

Teaching the TM to recognize 3 students with the PC's webcam shows students the construction of a neural network. Presenting a 4th student and observing what happens, enables to discuss biases. Discussing how a face recognition system like the one just built can be misused, highlights the ethical implications of AI.

Interested students can continue to explore Scikit-Learn on their own, if they wish. If these extensions and libraries appear as "black boxes" to students, they nevertheless enable us to develop Machine Learning programs in a few hours and without difficulties.

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Thus, students become aware of the use of AI techniques, its biases and ethical implications, moving from simple spectators to actors: from unconscious users to developers of Artificial Intelligence systems.

Keywords: Machine Learning, Python, Scikit, Learn, Education, Teaching AI, High School

AI and smart territory

AI for road safety

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In 2018, Inetum launched with the Association Prévention Routière and 4 other contributors "The New Observatory of Road Risks and Mobility (NORRM)" in order to contribute to the RPA's flagship goal of reducing the frequency and severity of road accidents.

This tool relies on Data Capture, Data Process and Artificial Intelligence technologies to capture and analyze the differences in road behavior according to many criteria, both "external" (weather, schedules, seasonality, proximity of places (school, hospitals, ...), infrastructure elements (bike lanes, speed bumps, ...), or related to road information (signs, speed cameras, ...)

Based on a mobile application, the capture of raw driving data avoids the use of equipment in vehicles, and thus reduces deployment costs and gains in agility in recruiting and managing "panelists". Thus, this application triggers the capture of raw data from the phone sensors when they are in a moving vehicle (GPS, Accelerometer, Gyrometer, Magnetometer, etc.) and sends them to a centralized platform that stores all this information.

This raw data is then cleaned and restructured and consolidated with external data (information on road segments, weather, etc.)

Different data processing algorithms coupled with AI models (pattern detection, clustering, satellite image analysis, etc.) then transform this refined raw data into "higher level" behavioral indicators (such as the time spent above the speed limit on a road segment, the detection of a change in behavior when passing a sign indicating a radar or a hospital, or the distance traveled to reach 50 km/h after entering a town, etc.). These algorithms will therefore make it possible to reconstruct indicators that even dedicated on-board equipment could have difficulty producing

These "high level" indicators will finally be crossed with declarative data to produce "comparative" infographics ("what the scouts say" / "what the scouts do") aiming at raising awareness of good practices on the road among all French drivers.

The last innovative aspect of the platform is that the panellist's smartphone will follow him throughout his journeys, unlike the equipment in a vehicle, making the solution "multimodal" by design. Thus, the application will be able, if desired, to reconstruct a journey using several modes of transport (walking, cycling, etc.), or only target certain modes. It can also manage the triggering and stopping of data collection according to several axes of analysis such as the geographical perimeter, days, schedules, types of travel (walking, cycling, vehicle, etc.), and the presence of beacons (in a bus, for example), making it possible to cover a very large number of

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cases while preserving the privacy of the data that can be collected.

NORRM therefore allows the comparison of declarative and real behaviors of drivers in the "scouting community" via a simple mobile application and an AI platform. In total, since April 2018, this Pathfinder Community of over 1400 people, has captured data from over 245,000 hours of driving covering over 4.5 million miles (June 2021 data).

Go behind the mirror with this session and come learn how AI is used and implemented on the NORRM platform!

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Keywords: Road safety, Smart Phone As A Sensor (SPAAS), Multimodality, Data Capture, Data science, Computer Vision

Artificial intelligence for smart water management: Prediction of water level variations in aquifers

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The use of artificial intelligence models to simulate and forecast groundwater has become more and more popular since the early 1990ies, as artificial neural networks (ANNs) have been shown to be effective for the identification of rainfall-water level (or discharge) relation prediction applications (Maier & Dandy, 2000). Groundwater resources are under increasing pressure due to large abstraction rates causing various issues such as water depletion, threats to groundwater-dependent ecosystems or saline intrusion in coastal areas. Climate change may particularly aggravate these issues in the Mediterranean region. Consequently, the development of models able to forecast groundwater levels is essential to support decision making, water resources management and climate change impact local assessments. Preliminary studies were carried out by the AI department of Atos Montpellier to develop a prototype able to simulate and forecast the piezometry (water levels), with the aim to adapt existing AI algorithms and set up a transferable methodology allowing quick implementation on different aquifers. The first study site chosen to develop a prototype of piezometry simulator was the Astian sands aquifer in the Occitanie region (France).
Different models were tested in this study, amongst them the Long short-term memory models and Echo State Networks. Current popular deep learning approaches include the long short-term memory (LSTM) and convolutional neural Long Short-Term Memory networks, recurrent neural networks which are widely applied to model sequential data like time series or natural language. LSTMs have the advantage to 'remember' long-term dependencies: they have a cell memory (or cell state) to store information and three gates to control the information flow. They have been used for rainfall-runoff modelling recently (Kratzert et al., 2018). Echo state networks (ESN) is a recurrent neural network with a non-trainable sparse recurrent part (reservoir) and a simple linear readout. The input weights and the connection weights in the ESN reservoir are randomly generated. The reservoir weights are scaled such as the reservoir state is an "echo" of the entire input history. This model have been tested in hydrological context with good performance (De Vos, 2013).

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In this study, the training was done on two thirds of the time series and validation and testing on the remaining data. Inputs variables were the daily rainfall data, temperature data and piezometry at daily scale. Different pre-processing methods were investigated including different filtering such as Savitzki-Golay and moving averages or sums. To validate the model and assess the performance of the simulations, different metrics were used. The loss function was the RMSE. Two hydrologic indicators widely used in the field were added: the Nash-Sutcliffe Efficiency and the Kling Gupta Efficiency. Finally the persistency criteria was used to assess the prediction.

The model achieving the highest performance was the ESN (RMSE of less than 2%, a Nash-Sutcliffe efficiency of 0.94 of and KGE of 0.97). The prediction was done in walk forward, using 2/3 of the data set to predict to following 20 days, and then iteratively predicting the next 20 days after reinjecting the predicted data and re-training until a prediction of more than 400 days was reached. To the confidence intervals of the predictions, to cross validate models and assess the stability of the model. Additional research is carried out on the pre-processing of the data (filtering), firstly with the aim of improving the performance and efficiency of the model, and secondly to investigate the ability of the models to simulate in a satisfying manner the time series including higher frequencies (piezometric variations over a few days and not averaged behaviour). The stability and robustness of the model is also investigated through additional cross validation, estimation of confidence intervals, and simulations in different hydrogeological contexts, to aim toward a transferable tool for various aquifers. This research is to be the basis for a global aquifer management platform for water administrations, and thus balance the different water uses at the catchment scale, anticipate droughts and mitigating the effects of climate change.

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Keywords: AI based water management, groundwater modelling, neural networks, reservoir computing, LSTM

Clever Hans meets solar panel detection : do intra-class variance and spurious features affect the performance of CNN based solar panel detection methods ?

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Despite remarkable performances, convolutional neural networks (CNNs) can experience large performance drop when used on new, previously unseen data. This problem of domain shift limits the ability of such methods to be used in practical settings. Recent work (Gulrajani et. al., 2021) showed that the minimization of the empirical risk (ERM, Vapnik, 1998), which consists in minimizing average of the loss function over the training dataset. This approach is a very strong baseline, often reaching state-of-the-art performance, for addressing domain shift. Thus, the problem of domain shift can be rephrased as a problem of out-of-distribution (OOD) generalization since unseen domains boil down in this case to unseen data drawn from distributions distinct from that of the training dataset. Domain shift can then be addressed by understanding the failure modes of ERM. A common framework for that is to isolate how ERM relies on both relevant and spurious or background features to make its predictions. So far, few works have provided examples of such relevant/spurious features in practical settings.
We focus on remote PV panel detection where another issue may come at play. Indeed, while the the semantic label "PV panel" is usually as a single class, it encompasses very different visual classes (dark or light-blue arrays for instance). Then we wonder how these different visual classes contribute to the feature learning of the model and how a shift in the distribution of these classes (PV panel types in our case) affects the performance of the network and limit the generalization to new locations. For instance, when facing dark arrays, a model will not resort on the same visual features than when facing light-blue arrays but will be eventually more prone to rely on spurious features (like e.g. a pool).

We place ourselves the experimental framework of Wang et. al. (2017), who considered two locations, Fresno and Stockton in California in order to document the fact that algorithms trained over a location can perform poorly to new regions. To isolate the different types of arrays, we leverage on k-means clustering using hand-crafted features derived from the arrays. This allows us to show that the distribution of the clusters (which correspond to the array's types) differs from one location to another. We then evaluate whether the amount of spurious features that is encoded by the learning algorithm during training differs with respect to the visual classes. This is done using mutual information, as recently proposed by Islam et. al. (2021). We will then evaluate the influence of the class of panel on the performance of the network and test the hypothesis that the there is a coupling between class of panels and spurious

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features. Indeed, this assumption would explain findings reported in previous works.

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Keywords: PV array detection, OOD generalization, domain shift, feature visualisation, feature disentanglement, remote sensing

Controlled deep learning powered image generation to adapt models to different production environment

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The great demographic growth of recent years has created major challenges to our lives and to our cities, such as car traffic jams, city pollution, energy consumption, city safety and so on. A lot of research on smart cities has been concentrated on finding solutions to these issues and a lot of effort were made to find solutions with various IOT technologies such as camera video protection, air quality sensors and so on. These devices produce massive amounts of data continuously.
The increase in data and processing speed have made artificial intelligent growing with the greatest speed in history by applying some techniques from computational intelligence to analyse such data in order to extract useful knowledge that will give to machines the ability to see, understand and interact with the world to make cities safer and smarter.

Deep learning, as a relatively new paradigm in computational intelligence, has attracted substantial attention of the research community and demonstrated greater potential over traditional techniques. Having a large dataset is crucial for the performance of the deep learning networks. However, we may lack the amount and diversity of data, so we use data augmentation with deep learning to control what we want to create, like transferring weather conditions from one image to another. We thought that if we manage to transfer the weather conditions, we can generate images with weather conditions that we can never have under normal conditions.

To address this problem, we develop a multi-domain weather translation approach based on generative adversarial networks (GAN), denoted as ProStarGAN, which can achieve the transferring of weather conditions from and to sunny, cloudy, foggy, rainy and snowy our model is a combination of two generative networks which are ProGan and StarGan hence the name proStarGan. StarGan is a model which has remarkable results in image-to-image translation and which satisfies the scalability over multiple domain and proGan is a model that leads to generate high quality images.

ProStarGan allows us to increase the data and also control the data we want to have. This data, which is generated thanks to artificial intelligence, makes our models more robust and have more knowledge of scenarios that we don't have yet.
In this demo we'll show you how deep learning can help us control the data we want to generate thanks to our model (ProStarGan). We will show you some successful examples of transferring

*Speaker

weather conditions from one image to another and the impact of these data on the robustness of our pose estimation model.

Keywords: smart, cities, data augmentation, generative adversarial network, image translation, weather conditions, high resolution, robustness, images

Giving life to fun characters to deliver services in public places through any type of sreen

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At Spoon we are giving life to characters on any type of screen (digital signage, TV screen, tablets, phone, ..) to deliver services and message to people in public place in a very intuitive, inclusive and fun way.
Our character **can see, listen, answer and react to people** in a very instinctive way.

Each of our characters embeds **primary, "animal" and emotional interaction capabilities** to provide the sensation of life and thus generate sympathy and facilitate engagement.

We are former founders of Aldeberan (and its famous robots Pepper and Nao) bought by Softbank Robotics a few years ago, an experience that has given us a lot of knowledge and expertise on human-to-machine interactions.

We already have deployed 30 characters in public places in France and Japan mainly (Toyota, Orange, LVMH, BNP Paribas, La Poste, Crédit Mutuel Renault, CNES ..) to animate them and deliver services.

IA capabilities: voice recognition, NLP, voice synthesis, face expression and gesture recognition

Keywords: smart city, collective intelligence, NLP, chatbot, marvellous

*Speaker

In-flight results of images processing by AI embedded on OPS-SAT

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During the Sophia Summit 2020 conference held last year, we presented the "Onboard image processing using AI to reduce data transmission: example of OPS-SAT cloud segmentation". In Sophia Summit 2021, we are proud to provide the in-flight metrics with two first in space: the processing by AI of images in orbit and the uploading of the code from ground!
Cloud segmentation is a useful onboard service to preserve the limited storage and bandwidth of nanosats. Indeed thanks to on board processing in close real time, it becomes unnecessary to download the complete RGB image to the ground but only the cloud-free areas. This use case was drive by several constraints:

- The OPS-SAT spatial resolution (53m at 600km) and the low sensor performances.

- The limited number of logic cells within its Cyclone V SoC FPGA.

We will also explain the major challenges we had to tackle to achieve OPS-SAT implementation, specifically:

- Dataset engineering, which was made difficult by the fact that no actual OPS-SAT images were available at the time of ANN trainings,

- ANN architectures selection, which was almost completely driven by the execution target capability and required to come up with tiny designs,

- Hardware acceleration of the trained ANNs, using a VHDL based solution specifically developed to target OPS-SAT FPGA on Cyclone-V System on Chip.

First we propose to remind how we implemented three Artificial Neural Networks (ANNs) on

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OPS-SAT SoC FPGA to perform cloud segmentation based on:

- A classical LeNet-5 architecture,

- A fully convolutional architecture,

- A hybrid convolutional / spiking architecture.

We will present also three new AI architectures implemented developed since last year and deployed on OPS-SAT System On Module:

- A fully spiking architecture,

- An evolutionary algorithm called Zoetrope Genetic Programming (ZGP),

- A hybrid convolutional/ZGP architecture.

Then, we will report and compare the in-flight inferences of each AI solutions.

We will also discuss the different parameters affecting the overall performance measured on board OPS-SAT, while presenting the impact of the different deployment steps on the inference metrics (in full precision on the CPU, quantified on the validation board or in-flight).

Some interesting information will be provided on the process that allowed, in coordination with the ESOC team, to download the complete experiment on board OPS-SAT: executables for the Hard Processor System (HPS) part, and bitstreams for the FPGA.

We will compare the processing times of the different solutions executed in flight. For this, we will detail the pre and post processing times on HPS as well as the inference time on FPGA. We will also compare the energy consumption of the different architectures tested in flight. And thus, if some architectures seem more suitable than others for the different metrics.

Depending on OPS-SAT availability before the conference, we could also present some in-flight results for Hybrid and Spiking Neural Networks or relevant improvements.

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Keywords: Deep Learning, System on Chip, FPGA, Satellite, On board data processing, Edge computing, Information extraction.

Investigating the hybrid use of operations research and machine learning tools in the pump scheduling decision-making problem

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In a drinking water distribution system - consisting of pipes, pumps, valves, storage tanks, reservoirs, and other hydraulic appurtenances - water is stored, treated, and then pressurized at pumping stations. Here, the pumps raise the water to elevated tanks and water towers, where finally it is supplied by gravity to local customers [1]. In this framework, we are concerned with *the pump scheduling decision-making problem*. This is defined as the optimal planning of pumping operations at the aim of minimizing the energy cost and satisfying the day-ahead demand. These optimization problems are usually very challenging. Indeed, along with the difficulty derived from selecting the pump status from binary variables at each time step, non-convexities arise from the static head-flow relations.

The resulting model is a large scale non-convex Mixed-Integer Non-Linear Program (MINLP), which is computationally intractable for standard mathematical programming tools.

To address this issue, we investigate the powerful combined use of tools coming from mathematical programming and Machine Learning [2]. In particular, our research is currently focused on the following subjects.

- We developed a branch-and-cut algorithm based on a polyhedral relaxation of the non-convex constraints [3]. Tightening the relaxation may be computationally expensive but is a key factor for the efficiency of the overall algorithm. Here it is where machine learning tools could come into play. A learning algorithm will be integrated in the branch-and-cut algorithm allowing *smartly* selecting the hyper-parameters of the relaxed MINLP [4].

- We explore machine learning techniques under the paradigm learning and branching. This means that machine learning heuristics should be able to extract meaningful information in each node and learn the best strategy for variable branching and/or node selection [5].

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Keywords: pump scheduling decision, making problems, mixed, integer nonlinear program, machine learning

Leveraging AI generalization performances to improve automatic plan analysis.

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The construction industry is evolving toward more modern tools to design and manage buildings. Thus, a new information model emerged and tends to replace 2D architectural plan, it is called BIM for Building Information Modeling. It includes 3D modeling and a lot of other tools to improve design. This approach is great for new buildings as architects directly design them with modern tools, but for older buildings which need to be renovated the conversion can be a very time-consuming and expensive process as it is done manually, because it is difficult to automate this process given the extensive variety of plans and the lack of standardization. Therefore, we propose to develop a semi-automatic tool to ease the process of converting 2D plans to 3D models with as much information as possible.
We first implemented classical computer vision algorithms to detect all elements of the plan, such as walls, doors, windows, furniture, text. The analysis is divided in three parallel parts. First The Text is segmented by OCR and removed from the image. Then the objects such as doors, windows, and furniture are detected and removed. Finally, the structural part of the plan (walls, stairs, ...) is extracted. Everything is then fused to create the 3D model. For example, we implemented template matching to detect doors, windows, and furniture. This works well on simple plans, but it does not generalize well. I.e., for a plan coming from a new source with different ways to represent elements it will not perform with the expected results.

To tackle this problem, we decided to train deep learning models. One which detect objects such as doors, windows, and furniture and another which segment the rooms of the plan. This approach allows to manage new plans easily thanks to the generalization capacity of deep learning and without being limited to given templates.

The models have been trained on a dataset composed 322 plans of varying quality. Which represents 9587 doors, 8026 windows, around 4178 pieces of furniture, 1754 staircases after data augmentation. For the most represented class the precision is around 90%. For the room segmentation it represents 8624 annotations and give 60% precision on masks and bounding boxes.

The use of deep learning models allows to improve the results of plan analysis. The generalization propriety of machine learning also allows to apply the algorithms to new types of plans.

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Keywords: BIM, Computer vision, CNN, Object detection, Segmentation, Template matching.

Redefine Experience at the Edge

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Edge Computing is being driven tremendously by the amount of edge data that's being generated by what is essentially close to fifty five billion data gathering devices. From small temperature and pressure sensors to high-resolution/high-frame rate cameras.
In just two years there will be 55 billion of such devices globally. And as you can imagine, now that it is so easy to capture vast amounts of detailed data, how we make good use of it becomes the new challenge.
We hear all the time about a data explosion, it's probably not a data explosion as much as is an ever expansive mass of data, because the more data we have, the better decision making we can achieve.-If we can make sense of the data. And do so quickly-where the data is created. At the Edge.

Half of all the data we create as a society will be processed at the edge. So the old days of the Data Center - or even the cloud - being the center of the universe is actually shifting to the edge. So it's important that we all understand what is edge computing because it is going to drive the next level of transformation.

Keywords: edge computing, AI, edge AI

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Self-supervised detection and analysis of cars in roadside Distributed Acoustic Sensing data

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Distributed Acoustic Sensing (DAS) is a laser-pulse technology that uses fibre-optic cables, like those used in telecommunication, to sense vibrations and deformation at fixed locations along a cable. Using DAS, fibre-optic cables of tens of kilometres can be turned into arrays of thousands of sensors (every few metres), sampled in time at several hundreds or even thousands of Hertz. This makes DAS a very attractive technology for numerous scientific and engineering applications, such as intruder detection, earthquake analysis, and infrastructure monitoring.
One of the many advantages of DAS, is that it enables sensing of commercial telecommunication cables. Commonly, telecom cables are deployed alongside roads, and these so-called "dark fibres" provide an opportunity to make measurements of the deformation induced by vehicles travelling along these roads. Looking at the deformation patterns recorded by DAS, we can detect individual vehicles and estimate their velocity using an array processing technique called "beamforming", enabling traffic analysis studies without a need for traffic cameras or the deployment of pneumatic tubes.

In dense traffic scenarios, which are rather common in urban environments, the distance between consecutive cars is relatively small, such that their deformation patterns overlap. This severely limits the time-resolution of the beamforming analysis, and consequently the ability to detect individual vehicles. The spatio-temporal extent of the deformation induced by a single car, as recorded by DAS, is physically constrained, but it is well known and is similar (up to a proportionality constant) for each car. These observations make the problem amenable to non-blind deconvolution, in which the characteristic deformation pattern of a car is treated as the impulse response that is to be deconvolved from the DAS data. Performing the beamforming on the deconvolved data permits a higher temporal resolution of detection.

In this study, we propose a self-supervised Deep Learning algorithm that performs multi-channel

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deconvolution of the DAS data. To this end, we design a U-Net architecture that takes the multi-channel DAS data as an input, and of which the output is convolved with the known impulse response of the cars. The learning objective is then quantified in terms of the L2-misfit between the input data and the convolved output of the U-Net, plus a sparsity constraint on the output of the U-Net. Consequently, a single forward pass through the U-Net can be thought of as a sparse, non-blind deconvolution operation.
After training the model, we deconvolve 24 hours' worth of data collected by a DAS system deployed alongside a major road near the city of Montélimar, France. Subsequent beamforming analysis extracts individual detections of cars travelling along this road (in either direction) and estimates their speed. For reference, we compare the detection performance on the Deep Learning deconvolved data with that on the original data, and on data that was deconvolved with a conventional, single-channel deconvolution algorithm (FISTA). We find that the detection performance on the Deep Learning deconvolved data is superior to that on the other data sets, with up to 5 times fewer false positive detections, and with the Deep Learning deconvolution also being more than 400 times faster than the iterative FISTA deconvolution procedure. This makes the proposed model an attractive algorithm for high-resolution and (near) real-time traffic analysis using DAS. More generally, the self-supervised Deep Learning model offers a very competitive alternative to conventional non-blind deconvolution algorithms, particularly in the case of multi-channel data.

Keywords: Distributed Acoustic Sensing, traffic analysis, nonblind deconvolution, self supervised learning

Smart Territory: Optimization of user experience in 5G network using AI

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Abstract summary
Guaranteeing high quality of user experience in emerging 5G networks has introduced new challenges needing the use of concepts like network slicing for IoT, transportation, healthcare and fast closed loops for automatic decision making. AI and ML are leveraged to ensure performance requirements and optimize the efficiency of the 5G core network in the utilization of resources and consumption of energy. The Network Data Analytics Function (NWDAF) has been introduced by standards bodies to provide analytics information to other 5G Core Network Functions (NFs) and enable such optimization. HPE is assembling a micro service complete NWDAF solution mixing leveraging analytics, AI and ML, to address use cases relating to smart slice load management, among several other applications.

1. Introduction

With the advent of 5G, new performance objectives such as latency (1 millisecond), data rate (100 Mbps, 20Gbps peak) and mobility (500 km/h) require mechanisms to guaranty high levels of network efficiency and user experience quality.

2. Fast closed loop for 5G with NWDAF

The new NWDAF micro service enables a "fast closed loop" inside the 5G control plane level, acting as a control system which automatically detects, infers, predicts, and decides to optimize the network.The NWDAF collects data from different NFs, leverages AI/ML to make predictions, and delivers notifications to other consumer NFs. It plays a role in the decision process and lets another NF or Management plane execute actions accordingly.

3. Guaranteeing user experience in a 5G slice

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To guarantee the user experience a high quality experience, the 5G network architecture is split into multiple logical and independent networks, named slices, which are configured to address use cases with distinct service level (SLA) requirements.Our prototype of the NWDAF "Slice load" service has been developed to predict the load that will be experienced by each slice configured in the network. The specific use case targeted is assignment of a user element (UE) to a slice, through the PCF (Policy Charging Function) and the NSSF (Network Slice Selection Function), facilitated by the NWDAF.

4. Implementing AI in NWDAF for 5G slice load prediction

The NWDAF workflow addressing the slice load service includes the 3GPP API for service subscription and notification, collection and transformation elements, tools for metric and event selection, prediction and rule/AI based decision analyses. The input metrics from NFs are evaluated based on correlation criteria to select the most relevant forecasting and decision steps. The prediction is based on univariate or multivariate models depending on the quality of the inputs. In the multivariate case, the dependency between variables is also used for forecasting the future values of the target metric. A consolidated AI driven notification decision is introduced to increase the decision relevancy using sophisticated analytics models as Directed Acyclic Graph (DAG) and ML based classifications.

Conclusion

As 5G is extensively deployed in Smart Territories, smart network slice assignment will become necessary to address the high level of SLA requirements. Fast closed loop analytics, provided by the NWDAF, is the key enabler for this real time automation. The use of AI technologies in the 5G CORE network through the NWDAF will guarantees a high quality of user experience for the emerging innovative applications and users of applications of the 5G network.

Keywords: 5G, AI, Analytics, User experience, Mobility, Prediction

TerraOccitanIA: From text recognition to soil map generation

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Knowledge of soils is essential for dealing with agro-environmental issues, particularly in food security, climate change mitigation (soil CO2 sequestration).

To extend the soil knowledge spatially, digital soil mapping (DSM) [1,2] aims to use available soil databases to map soil primary properties globally, over the past decade. However, the outcomes of DSM do not reach the requirements of decision-makers for two main reasons: i) the current soil databases are not dense enough to produce high-resolution soil maps that are essential for decision-makers and ii) the need to move from soil primary properties to soil indicators (e.g., the soil available water capacity (SAWC)).

The well-known first issue in DSM studies is the soil observations density. Despite considerable efforts to digitize legacy soil data, a large amount of it remained unused. The mobilization of such an important soil database could be used to overcome the low-density situation and to avoid starting new expensive harvesting campaigns, and, finally to produce high-resolution and accurate soil maps for the decision-makers.

Furthermore, DSM studies are currently moving from soil primary properties to required soil indicators. Providing a map of soil indicators could help to preserve soils with high agricultural potential, high carbon stock capacity, or high-water storage capacity.

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The Terra OccitanIA project aims to overcome this issue by using the legacy soil dataset from the BRL company. From 1956 to 1992, the BRL company had harvested 228,000 soil observations over the Languedoc plain (6,636 km2).

This project will follow the first experimentation led by Styc et al. [3,4] which led studies from digitizing by hand the legacy soil data of a commune to the production of high quality and accurate SAWC map, e.g., the soil capacity to store water for plant growth. However, those studies addressed a limitation: the high time consumption of hand digitizing and advised to move forward a semi or complete automation.

The Terra OccitanIA project will be articulated in several major steps: i) improving the digitizing of BRL's legacy soil data by automation through AI methods or text recognition, ii) producing SAWC over the Languedoc coastal plain and providing performances (accuracy) indicators of the produced map, iii) mapping other soil indicators required by decision-makers (e.g., carbon storage capacity), and iv) defining a digital platform to share and disseminate the products.

Keywords: Artificial Intelligence, Machine Learning, Soil Available Water Capacity, Digital Soil Mapping

Towards a Distributional Reinforcement Learning approach to Revenue Management

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Revenue Management (RM) is the research field which is concerned with the control of supply and demand in order to maximize revenue through pricing decisions. Today, to predict future demand and perform price optimization, Revenue Management Systems (RMS) use demand models often handcrafted by research teams. Even though such models are very complex, there are many important complexities of the real-world customer behavior that are often not considered.
As shown by (Bondoux, et al., 2020; Lawhead & Gosavi, 2019), removing model assumptions by making use of *model-free* Reinforcement Learning (RL) methods can bring important improvements to RMS. In particular, deep Q-learning (DQN) (Mnih, et al., 2015), which trains a neural network to represent the optimal state-action *value* function (i.e. the expected long-term cumulative rewards for each possible state and action, assuming an optimal strategy is followed afterwards), enabled human-expert level performance when playing classic Atari 2600 computer games. However, applying such RL breakthroughs to the field of RM is very challenging. One of the reasons is because the variance of the reward signal (the revenue) is often much larger than the difference between the optimal state-action value for the different state-actions, making their disambiguation difficult. Consequently, RL agents need very large amounts of data to learn any useful policy, which is often not available in the real world.

Distributional Reinforcement Learning (DRL) (Bellemare, et al., 2017) extends the value-based approach of DQN by considering the full value distribution as a learning signal which considers all the complexity of the randomness coming from the rewards, the transitions and the policy, which is hidden when considering the mean only. Even when a policy aims at maximizing the expected value, considering the full distribution as a learning signal provides an advantage in the presence of approximations, allowing to improve action-state disambiguation.

DRL methods learn the value distribution using a temporal-difference approach, i.e. by matching the value distribution at a given state with the combination of the value distribution at the next state and the distribution of immediate rewards-the so-called *distributional Bellman operator*, whose contraction properties are key for guaranteeing the stability of DRL algorithms. DRL algorithms are typically neural network-based and require two key elements: a neural network-based representation of the distributions and a notion of distance or divergence between distributions suitable for gradient-based minimization. As shown in (Dabney, et al., 2018) for Atari games, these design choices can significantly affect the performance of these algorithms.

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In our work, we investigate the suitability of DRL algorithms to the Revenue Management problem, in terms of stability and learning speed. As future research, we plan to investigate how the learned distributions can be used for risk management purposes.

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Keywords: Revenue Management, Model, free Reinforcement Learning, Distributional Reinforcement Learning

Use embedded systems adapted pose estimation and action recognition to achieve the Safe City of tomorrow

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Present-day cities are able to generate precise information about a person through deep learning and video analytics, unlocking new perspectives for action recognition in urban scenarios in context of the protection of individuals. Various application cases are possible, such as fall detection or aggressive behavior detection, whose frequency tends to increase due to more general problems such as population growth, demographic change or urbanisation. Crossed with other deep learning techniques, we can now provide a rigorous urban scene understanding.
The state-of-the-art methods usually use a primary model for human pose estimation and a secondary model for action recognition. Pose estimation is a computer vision technique that detects human poses in images and videos. Although the recent work models can perform in real-time on most computers, they still achieve poorly on embedded systems for more than one stream. We have designed a lightweight Deep Neural Network-based Real-Time Pose Estimation which allows us to deal with multiple urban cameras, this enables efficient secondary processes such as gesture and activity recognition in urban scenarios.

We have therefore also developed a posture classification model in-favor-of real-world scenarios, fed with numerous data and robust to non-standard data. This model is location-viewpoint invariant and very light, allowing multi-person posture classification with high accuracy.

Both these models can adapt to totally different domains, which is particularly suitable for smart-cities with a diverse and rapidly-changing environment. Our pipeline which contains these models can be deployed in many places : industrial zones, hospitals, sports meeting places and any vulnerable public areas.

In this demo we'll show you how our human pose estimation model and our posture classification model can deal with health surveillance to provide safety. We will show you its accuracy, efficiency and usefulness through various classic examples.

Keywords: pose, posture, estimation, classification, action, recognition, fall, detection, real, time, urban, camera, gesture, activity, embedded, crowd, multi, person, smart, city, human, behavior

*Speaker

AI and biology

Deep Learning to predict the L-PART1 exon within immunoglobulins and T cell receptors

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Identifying and annotating Immunoglobulins (IG), T cell receptors (TR) genes of jawed vertebrate species effectively and precisely is still an arduous task, essentially due to the continuous avalanche of large genomic sequences produced by the latest sequencing technologies, such as NGS [1]. In this study, we are interested in predicting the L-PART1 exon (the first exon of IG and TR variable V-GENE), for this aim, different Deep Neural Network-based models (DNN, CNN, RNN, CNN-RNN) were implemented, trained in a supervised manner, which automatically learn features from annotated IG and TR genes. Those models are then inferred to predict the L-PART1 exon within newly given sequences. A correct detection of this component would dramatically increase the chances of finding the subsequent components constituting the V-GENE of the IG and TR. As a result, the annotation of new IG and TR genes may become fully automated, faster and easier. Our models were trained with the help of IMGT/LIGM-DB [2] database, for which they showed promising results. However, further studies are being conducted to investigate the possibility of predicting and locating all the components within the V-GENE of IG and TR.

Keywords: Deep Learning, Neural Networks models, Immunogenetics, Immunoglobulins, L, PART1, VREGION

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Odorant receptor ligand prediction via graph neural networks and representation learning

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Our sense of smell relies on the use of approximatively 400 genes expressing functional odorant receptors (ORs), endowing us with the power to discriminate a vast number of chemical stimuli. ORs are activated by molecules, called ligands, in a key-lock mechanism where a ligand fits into the OR's binding cavity. One molecule can fit in different OR's binding cavity and ORs can accept several different classes of molecules.
Establishing a relationship between the structure of a molecule and the structure of OR that it activates is a long-standing problem. To date, common procedure for OR's ligand identification has been based on in vitro search with rather low success rates of approx. 3%. Moreover, the data linking a molecule to a set of ORs are scarce and only 131 ORs have an identified ligand. Thus, building a machine learning protocol taking ORs' sequence explicitly remains challenging. To tackle this issue, we leverage recent advances in representation learning and combine them with graph neural networks [1] (GNN) to build a receptor-ligand prediction model. To the best of our knowledge this is the first model for ORs' ligand prediction that takes an entire protein sequence into account.
Several methods inspired by success of representation learning in the natural language processing (NLP) have been proposed to represent protein sequences. Here we represent ORs using architecture based on BERT [2] which was previously trained on more than 200M protein sequences. We use the BERT's classification token embedding as an initial receptor representation. We treat molecules as graphs and process ORs and molecules simultaneously using GNN. In general, distant atoms in the molecule can interact differently with the OR. In order to account for this, we copy and concatenate OR representation to every node of the graph to facilitate its local treatment.
Our receptor-ligand prediction model has been evaluated on a set of more than 7500 OR-molecule pairs. The model is achieving a Matthews correlation coefficient (MCC) of 0.40 in the case that all receptors are included in the training set (i.e. random split). The performance on a much more difficult deorphanization task (i.e. discarding all pairs of a given receptor – out of distribution prediction) remains acceptable with a value of 0.27.

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Keywords: Computational Biology, Graph neural networks, BERT, Olfactory receptors, Molecular modelling

IA and management

A Multi-criteria Approach to Evolve Parsimonious Neural Networks for Stock Market Forecasting

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A new approach to evolve parsimonious neural architectures is proposed. In particular, the network sparsity is approached in terms of various topological attributes such as size and number of hidden layers. This concept is extended further by integrating the classical feature selection problem as a part of the neural architecture design and by expanding the definition of network sparsity to include the cardinality of features. Such networks are evolved by approaching the neural design as a multi-criteria decision-making problem to balance the efficacy and sparsity of the evolved networks. Further, a new search paradigm, Two-Dimensional Swarms (2DS) is proposed for the multi-criteria neural architecture search, which explicitly integrates sparsity as an additional search dimension in particle swarms. The efficacy of the proposed approach is evaluated by considering the challenging problem of predicting a day-ahead movement of the NASDAQ index using various technical indicators as inputs. Multi-dataset learning is also considered to capture the index behavior prior to as well as after the 'market plunge' marked by the ongoing COVID-19 pandemic. A detailed comparative evaluation is carried out by considering several baseline approaches such as ReleifF, and mRMR as well as Genetic Algorithm and Binary Particle Swarms. The results of this study convincingly demonstrate that the proposed approach can evolve parsimonious networks with better generalization capabilities.

Keywords: Feature Selection, Financial Forecasting, Neural Architecture Search, Multiple Criteria Decision Making

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Artificial Intelligence, Ethics, and Intergenerational Responsibility

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Humans shape the behavior of AI algorithms. One mechanism is the training these systems receive through the passive observation of human behavior and the data we constantly generate. Although AI was developed to improve human well-being, it might exhibit biases or inefficiencies in some of its predictions. If this occurs, the fault will lie – apart from their programming – mostly in how the algorithms were taught and trained. Indeed, many AI systems learn from human choices of today to augment decision-making of tomorrow. Biased predictions could thus result from contamination of the training data – for example through feedback loops or discriminatory choices – that then substantially affects the decision-making of the algorithm. As long as our society exhibits biases or unethical behavior, these biases should be reflected in the data that are collected and the choices self-learning algorithms make for us and for others, today and in the future. Hence, focusing on the transmission of social preferences, our first research question is: how does human behavior that expresses selfish versus prosocial preferences react to the use of today's decisions for the training of an AI that will make decisions in the future? Our second research question asks: Is it possible to strengthen individuals' sense of responsibility by emphasizing the consequences of training on the well-being of future generations?
This study contributes to the recent literature on AI and ethics by highlighting the training aspect of AI and its ability to operate across individuals and generations. Observational data, when they exist, do not allow us to exogenously vary the externalities generated by the training of AI. Therefore, we designed an online experiment with a sequence of dictator games, in which we let participants' choices train an actual random forest algorithm and provide them with transparent information about this training. Thereby, they create an externality on future decision-making of the intelligent system that affects themselves and potentially also a future generation of participants. We manipulated the concern for future participants and tested whether an externality of today's training of an AI algorithm that would make decisions in the future influenced today's individuals' social preferences and decisions.

We find that making individuals simply aware of the consequences of their training on the well-being of future generations does not change behavior. However, behavior changes dramatically when relative positions for an algorithmic prediction become uncertain, to a degree that cannot be explained by expected payoff maximization alone. When individuals bear the risk

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of being harmed themselves by future algorithmic choices, the externality of training artificial intelligence induces higher preferences for fairness in the present. Participants take (i) the efficient option more frequently even if this choice decreases their own immediate payoff, (ii) the selfish option less frequently even if their own payoff is lower than the one of the receiver in both options, and they choose (iii) the altruistic option more often if it reduces inequity and is fairer compared to the alternative.

Our findings reveal that intergenerational responsibility in human behavior when training an AI is difficult to induce and cannot be triggered by information alone. It was only in settings where individuals understood that there was a risk of being negatively affected by immoral algorithmic decisions (through harming a future participant) that they considered intergenerational transmission of data when teaching the machines and exhibited less selfishness. Uncertainty regarding both, their own future earnings and the earnings of an individual in a future generation of participants, allowed subjects to be more considerate. In this case, they put higher weight on the others' outcome when making decisions that also served as training data for a machine learning algorithm.

Link to paper: https://ssrn.com/abstract=3853827

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Keywords: Experiment, Ethics, Social Preferences, Generations, Externalities, Human Decision Making

Customer reaction to robot anthropomorphism in frontline service

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Advances in Artificial Intelligence are vastly extending the capabilities of machines. Their deployment in frontline service leads to new service archetypes where employees can be substituted or augmented by these technologies (De Keyser et al. 2019). Indeed, AI systems are able to complete numerous tasks ranging from basic ones requiring mechanical intelligence to more sophisticated jobs requiring emotional intelligence (Huang and Rust 2018). Thus, it is essential to examine customer response to robots capable of or appearing to have feeling abilities. In this research, we contribute to filling this gap by examining a basic component of robots' perceived emotional intelligence: the robot's perceived ability to have feelings. We investigate the anthropomorphic features that lead customers to attribute human-like mind to robots. We examine the robot face specifically as a predictor of perceived human-like mind and the consequent customer emotional response (irritation) and behavioral response (intention to use the robot in a service environment). We inspect these effects in the absence of body (study1), and in the presence of body (study2). We find that the face generates a perception of the robot agency only in the presence of body, while it generates a perception of the robot experience abilities in both absence and presence of body. We confirm this counterintuitive finding by manipulating the robot body in study3. To the best of our knowledge, the effects of these anthropomorphic dimensions on mind perception have not been examined specifically.

LITERATURE REVIEW

Gray, Gray, and Wegner (2007) suggest that mind perception can be decomposed into two dimensions: agency and experience. Agency refers to the capacity to act and do, and to cognitive capacities (Gray and Wegner 2012). Experience refers to experience abilities and capacity to feel and sense. Assigning agency and experience are common attributions in anthropomorphism (Epley et al. 2007, 2008). It is acknowledged that the design plays a major role in attributing mental life to inert objects (Scholl and Tremoulet 2000) and robots are no exception to this phenomenon. Previous research examined the robot's physical anthropomorphism as a one-dimension construct, while it can be decomposed in three distinct categories: surface look, body-manipulators, and facial features (Phillips et al. 2018). The Theory of Mind (Baron-Cohen, Wheelwright, and Jolliffe 1997) state that facial features are crucial in attributing mind

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to others. Subsequently, we propose: A robot with human-like face (vs control) elicits a higher perception of experience abilities (H1) and agency (H2).

Experience abilities are considered as a discriminating factor between humans, as an in-group, and other species as out-group (Chalmers 2003; Dennett 1996; Haslam 2006). Robots with experience abilities can be perceived as blurring the intergroup boundaries between the humans and machines, and thus trigger irritation. Furthermore, the uncanny valley theory (Mori 1970) confirms that displaying robots with feelings can violate deep-rooted expectancies (Olson et al. 1996) about humans and machines. Thus, we propose: The perception of a robot with experience abilities generates feelings of irritation (H3). The more customers experience irritation, the less is the intention to use the robot in service settings (H4).

We know from the Technology Acceptance Model (TAM) literature (Davis, Bagozzi, and Warshaw 1989) that the perceived usefulness is a predictor of technology adoption. Thus, we propose: The more a robot is perceived with agency, the greater is the intention to use the robot in the service setting (H5).

METHOD

We selected robots from the ABOT database (Phillips et al., 2018) for each experimental condition. Participants imagined interacting with it in business school reception desk. We examine the effects of face in the absence of body-manipulators in study 1 then in the presence of body-manipulators in study 2: 149 participants were randomly assigned to robot with face (vs control). In study3 we examine the effect of the body in robots displaying a face: 83 participants were assigned to a robot with body features (vs control).

We used customized model of Hayes's (2017) PROCESS macro for SPSS (version 3) with 5000 bootstrap sample to test the conceptual model. The unstandardized regression weights for estimated paths are presented in Table1.

DISCUSSION

Unlike previous research, where the general concept of the robot human-like appearance was manipulated broadly, we examined the distinct effects of the anthropomorphic factors: face and body. We find that face generates a perception of the robot's experience abilities regardless of the presence or absence of body features. Contrary to what was expected, facial features do not elicit a perception of agency in the absence of body. Displaying face and body on robots generates a perception of both agency and experience abilities. Surprisingly, perceived experience in the presence of body features does not create irritation. Similarly to research on algorithm adoption (Castelo et al. 2019), we find that when the robot is perceived as competent, the feeling of unease is attenuated. We confirm that effects of perceived usefulness from TAM remain valid for service robots; the robot perceived agency increases the intention to use the robot. Future research should investigate assigning feelings to robots as an antecedent to hostile attitude toward robots.

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Keywords: Service robots, Anthropomorphism, Frontline Service Technology, Human Robot Interaction, Mind Perception

Explainable AI for Assessing SMEs Credit Default

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In this paper, we propose a methodology to bridge the gap between Credit Risk modeling in the Small Medium Enterprises context and Explainable Artificial Intelligence.

The ability to predict corporate failure has been largely investigated in credit risk literature since the 1970s. Recently, credit institutions are gradually embracing Machine Learning techniques in different areas of credit risk management, credit scoring, and monitoring. However, such techniques have been applied mainly in order to improve classification accuracy with respect to the standard linear models, rather than in terms of causality patterns. But the latter is no longer a negligible aspect, both for academic research and for management of regulated financial services: it has become overriding since the European Commission and other European Institutions released a number of regulatory standards on Machine Learning modeling. The difference in meaning between interpretability and explainability, synonymous in the dictionary, has been addressed by the recent Machine Learning literature which recognizes the two words as a conceptual distinction related to different properties of the model and knowledge aspects. Another challenge posed by such modeling is that generally, black-box models are capable of capturing nonlinear relationships among the features in spite of standard statistical models such as logistic regression and linear discriminant analysis. However, the problem of transparency and interpretability is a major one when it comes to delivering the model to production.

Because of this, we focus on making such models interpretable from the start by using model agnostic approaches. Although a strong debate on the usefulness of black-box models in the first place, in many use-cases, black-box models allow for better performance, as in the field of credit risk. The literature about Small Medium Enterprises' default prediction covers a variety of case studies and methodologies, from Logistic Regression to Machine Learning models, that show remarkable performances at the expense of interpretability of the estimated rules.

In this paper, we model Small and Medium Enterprises' default using relevant Machine Learning techniques such as the eXtreme Gradient Boosting and the FeedForward Neural Network algorithms.
First, we propose a multidimensional merit function that will maximize discriminatory power in the context of high-class imbalance instead of the frequently used log-likelihood functions.
Second, we develop a hyperparameter tuning routine based on Multicriteria Optimization, this new approach will allow the decision-maker to fine-tune its models to achieve a performance that complies with the peculiarity of its business and its risk attitude.
Third, we compare the performance of these new modeling pipelines with standard models used

*Speaker

in the field, namely Logistic Regression and Probit Model.
Fourth, we employ recent model-agnostic techniques, such as Accumulated Local Effects and Shapley values, to further investigate features' effects on models' outcomes.

Keywords: Explainable AI, Credit Risk, Classification, Supervised Learning, Model Agnostic, Machine Learning

How to turn data science practices into workflows: application to anomaly detection

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Solving real-world business problems using data science (DS) typically involves three steps: First, better identify the business problem through data analysis; Second, precisely design the right DS workflow (i.e. data selection, preprocessing, data transformation, model selection, and evaluation); Third, ensure that it is properly deployed, manage its lifecycle, and put mechanisms in place to ensure its proper use in production.
The first step is usually overlooked in the literature, the focus is on steps 2 and 3.

Characterizing the problem and understanding the data better is crucial to make decisions later on when building workflows. As an example, categorical data is sometimes defined over natural values and mistaken as a numerical field, so the data scientist is unlikely to apply methods proper to categorical data like 'one-hot encoding'.

In this situation, each data scientist uses her own tailor-specific practices or eventually shares some experience with her colleagues. In fact, they are building a set of knowledge, based on experience and bibliographical work. Going through this process individually from scratch each time is time-consuming and challenging.

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To improve this process, we propose to design a smart generator of DS workflows. We focus in this work on designing workflows for anomaly detection problems. Such a system requires to absorb the implicit practices of individual data scientists, and to enable collecting a comprehensive knowledge, by :

(i) Identifying the best questions to ask the end-user, to gather the most important information about the problem. Experienced data scientists acknowledge it is not obvious since it implies knowing deeply enough what you are looking for (e.g. what makes a sample an anomaly or not), and being able to characterize it in the client's lexical field.

(ii) Identifying the variability: understanding the possible similarity between the current problem under investigation and previous anomaly detection solutions, in order to capitalize on past experiences.

(iii) Incrementally evolving: It is impossible to tackle all existing anomaly detection problems at once. Therefore we do not pretend to aim at a perfect system that covers all anomaly detection issues. Instead, we look forward to building a system that is capable of incrementally evolving. Each time a data scientist encounters a new dataset, the system should absorb newly discovered knowledge and spot any kind of conflicts.

The objectives are then similar to developing a software product line [3]. The application engineering process is then clear: exploit the variability of the product line to ensure the production of the suitable DS workflow according to the specific needs of the application. Building such a line is a challenge. It requires a domain abstraction step to characterize the commonalities and variabilities between problems and solutions. However, the problem space is not only very large, even when restricted to anomaly detection, the solution space also evolves very quickly. A portfolio approach [2], commonly named meta-learning in DS domain, is not satisfactory either for similar reasons, plus the computation and memory requirements. Auto-ML approaches do not meet step 1 either [4], because the choices on data preparation remain very specific to the business problem and without it, in industrial cases, tools such as Auto-ML are useless.

Based on these previous works, we aim at designing an abstract model of data scientists' processes, to capitalize on the knowledge and practices of data scientists from Ezako case studies and those found in the literature.

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Keywords: Machine learning workflow, Software engeneering, AutoML, User experience

Innovation and the Asymptotic Rationality of Artificial Intelligence

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Abstract

Burgeoning conversations in economics, sociology, and management are pondering the consequences of the advances of artificial intelligence (AI). One area of interest is the management of innovation, where –for established and new ventures alike– the potential impact of AI on engineering, product development, and marketing seems significant.

This line of research sees innovation as a search process in which boundedly rational actors explore a solution space determined by a focal problem to find a problem-solution pair (Cyert & March, 1963; Simon, 1955). In this view, AI promises to speed up the identification of new solutions, through faster discovery and evaluation of alternatives in pre-defined search spaces. Thus, AI could be understood to overcome the constraints of human rationality limiting innovation.

However, we argue that finding true novelty remains a challenge for current AI. We refer to true novelty as innovation outside of existing solution spaces, with transformative –not incremental– findings as entirely new problem-solution pairs.

Acknowledging a possible future existence of general AI (Tegmark, 2017), current AI still relies on algorithmic rules and clearly defined starting points in the form of training data from where search begins. For innovation, this implies agreed-upon problems; pre-defined search spaces. To produce truly novel solutions, agents need to step outside of this space, and find new starting points. Humans typically do this by drawing on unarticulated preferences. We argue that AI does not have this ability.

- Figure 1 here -

To capture these characteristics, we introduce the concept of asymptotic rationality. Although current algorithms will not produce true novelty, they can asymptotically increase the rationality of search within existing solution spaces. We propose three mechanisms which allow AI to become asymptotically rational:

Meta cognition: AI may generate new solution data by applying generative models, e.g., heuristics or means of abstraction. They may then search beyond pre-defined spaces and include

*Speaker

previously unattractive solution alternatives as possible matches for a given problem.

Enforcing preferences: AI may introduce new problem data through imagination, i.e., associating plausible problems to match existing solutions. This could enable AI to shape customer preferences through targeted campaigns and create new markets for existing solutions.

Rapid micro-experimentation: Relying on a process of learning and improvement, AI may generate new data by independently and iteratively searching for problems and solutions, i.e., inferring one from the other; using one as training data. While this is still sequential, leveraging the prowess of algorithms allows for an acceleration of iterative cycles to discover previously unrelated or unknown problems and solutions, or achieve creative leaps when finding entirely novel pairs.

- Figure 2 here -

Our argument has three key implications. Firstly, an AI searching a pre-defined space will instantly consider all possible alternatives, making the distinction between local and distant search disappear. For organizations, this means that the acquisition of data to define existing search spaces becomes an essential task.

Secondly, this implies a re-definition of managerial roles. Managers will transition from decision-making and problem-solving to problem-definition. They will also need to ensure the functionality of their digital assets, e.g., by addressing concerns around ethics and biases of technology (Balasubramanian et al., 2020).

Thirdly, we contribute to the debate around de-skilling of the workforce (e.g., Autor, 2013). With AI speeding up incremental innovation, humans may no longer have the routines to collect necessary training for creative thought through serendipitous genius. We call on managers to ensure that the human work experience and creativity is not stifled in the pursuit of automated efficiency.

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Keywords: Innovation, Organization theory, Novelty, Search, Bounded rationality, Problem solving

Role of Patents and Trademarks in funding and revenue generation of AI startups: a cross-market study in EU, Asia, and the US

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The purpose of this research is to understand whether patents and trademarks are significant drivers of funding for artificial intelligence (AI) startups by venture capital firms (VC) and whether those help in driving revenue generation for these startups. Data of 573 startups across Europe, the US, and Asia were taken from Crunchbase and fitted using a Generalized Linear Model (GLM) to understand the significance of patents & trademarks. The results indicate that while both variables play a significant role, especially in Europe, AI startups prefer trademarks in the early stage.
Specific to Europe, an illustration of this is that while the Venture Capital (VC) value patents higher, only 25% have filed for patents, whereas 76% have registered trademarks. This phenomenon of preference for trademarks may have a broader implication on the future growth of these startups and the economy's overall growth.

EU (2019) briefings referred to AI as an engine of growth in Europe, expecting it to double the growth rate by 2035. European Investment Bank (EIB,2021) extended the discussion on the importance of AI e by including the importance of Venture Capital (VC) infrastructure, implying the importance of AI startups. Previous research had indicated that startups are essential for growth as they play a critical role in introducing radical technology that leads to economic growth (Colombelli & Quatraro, 2019; Fukugwawa, 2018).

Previous research has indicated that patents and trademarks are significant drivers of funding and help drive revenues. Zhou et al. (2014) viewed patents and trademarks as technological and marketing signals that should positively impact an AI firm's growth and funding. Important to note that the treatment of patents and trademarks varies across Asia, Europe, and the US. In Asia, trademarks have to be registered locally in each country. Asian laws protect unregistered trademarks if they have gained goodwill (European Commission, 2020). Research of patents in the US indicates that an absence of a previous artifact can lead to a patent grant (NBER, 2002).

Total 573 startups across Europe, the US, and Asia were analyzed to understand the drivers for revenues and funding. Of the 573 startups, 258 were Europe based, 179 were US based, and 136 were Asia based. Among the 258 European startups, 120 were funded only through VC, while 138 AI startups were funded through a mix of debt and VC funding. GLM was used for

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analysis as the data failed the normality test. The model included both patents and trademarks as drivers of both funding and revenue and their interaction with late stages of funding and other variables such as signals and M&A. Both patents and trademarks were considered dummy variables in the models.

The results show that patents and trademarks are essential drivers for funding European AI startups primarily funded by VC. Patents are valued more by 30% as compared to trademarks by the VC partners. For AI startups partly funded by debt, patents are not a significant contributor to the overall funding. Thus, EIB's (2021) focus on VC is validated. Only trademarks are significant as drivers for revenue. Patents granted in the later funding stage(captured as an interaction variable) results in revenue reduction.

For Asian AI startups, patents and trademarks are significant drivers of funding, with patents having a 40% higher coefficient than a trademark for VC funding. Patents also drive revenues, but the interaction between late-stage funding and patents has a negative coefficient. For US AI startups, VCs value trademarks and not patents, and only trademarks influence revenues. The NBER (2002) findings could explain the lack of significance of patents in the US.
Patents' lack of impact on revenue has a vital significance for the plan for AI startups, as engines of radical technology, driving growth. While patents are not a significant factor across both funding & revenue in the US, in both Europe and Asia, the interaction between late stages of funding and patents reduces revenue. Further, in Europe, patents are not significant as a driver of revenues. The results may indicate that AI startups are challenged in the commercialization of patents, as indicated in previous research (Halle et al., 2014). Challenge in commercialization may be the reason that in Europe, within the sample of 120 startups, only 25% filed a patent while 76% registered a trademark. EU (2019) may need additional steps to double the economic growth rate with AI startups as drivers of this growth.

Keywords: Artificial Intelligence (AI), Venture Capital (VC), Trademarks, Patents, Governance, Management

Talking to bots on Twitter

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The proliferation of online social networks (e.g. Facebook, Twitter, etc.) has created significant challenges for modern societies. One of them is the easiness of implementing automated accounts (hereafter bots) who could pedal certain type of content through the network without regard of the veracity of this content. Majority of Bots reply on simple AI algorithms for operation. Their activity has been explicitly linked to disinformation campaigns during the run-up to 2016 US presidential elections [1], as well as in other digitally-intensive political processes outside the United States [2]. The fact that they contribute to a larger problem of spread of fake news, low-credibility and inflammatory content is without a doubt [3, 4, 5].
Yet, not much is know exactly who interacts with bots and how (if at all) does this interaction alters their behavior on social networks themselves. Do these people increase their engagement on the platform (i.e. social network) as a result of interaction? Is this increase long-lasting? Are they able to generate more engaging posts? In other words, what is the social impact of AI technologies involved in automated bots. In this work we attempt to answer these (and related) questions by using an extensive data set of Twitter users who have interacted with a recognized bot. A list of 2,752 malicious bots that were shut down by the platform was forwarded to the United States congress and made public in November 2017. We have identified the 55 most influential bots from this list. We have further identified twitter users who have interacted with these bots. In order not to pollute the results with multiple interactions, we study the subset of Twitter users who have interacted only once with one of these 55 bots.

The main statistical challenge is identifying an appropriate counterfactual to which target user behavior should be compared. Matching (either exact, coarse exact, or propensity score) across Twitter users is not feasible as it requires collecting data on extensive part of Twitter users who have not interacted with bots. Appropriate methodology for identifying such users is not obvious. An alternative way for estimating relevant effects is to use only the data of bot-interacting (treated) individuals and take advantage of the fact that they interact with bots at different points in time. We use the latter approach. Even in such a case, a major computational challenge of estimating a Poisson model on a large panel remains.

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Keywords: Twitter, Automated bots, Interaction, Behavior

The augmented entrepreneur? The influence of artificial intelligence on human entrepreneurial creativity.

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With the development of artificial intelligence (AI), exploring how entrepreneurs can be augmented is a new stake. This paper addresses a direct call from entrepreneurship scholars to understand how different AI systems influence idea generation (Chalmers et al., 2021). Entrepreneurs process information during idea generation to identify an opportunity. The goal is to seek a mechanism through which AI systems can enhance this difficult step. Drawing on the dynamic componential model of creativity (Amabile and Pratt, 2016) as well as prior work from management scholars on AI and creativity, stimuli generated by creative AI systems are predicted to have a positive influence on one creativity-relevant process : cognition. In order to identify the underlying cognitive mechanism, this paper uses cognitive theories of creativity, especially the dual pathway to creativity model (Nijstad et al., 2010) and the search for ideas in associative memory (SIAM) model (Nijstad and Stroebe, 2006). The paper also builds on a rich literature on creativity support systems to spot what characteristics a creative AI system must have to stimulate cognition. A conceptual model applicable to creative AI systems trained on diverse datasets is described. The model posits that cognitive flexibility, which is the ease with which people can switch to different approaches, mediates a positive relationship between the use of creative AI-generated ideas and six outcome variables during idea generation. These six outcome variables are creativity, novelty and usefulness of entrepreneurial ideas as well as the number of creative, novel and useful entrepreneurial ideas. The mediating role of cognitive flexibility was tested (n=90) through an online randomized experiment. The study deployed a one-way between-subjects experimental design. Participants with an intermediate knowledge of entrepreneurship were immersed in an entrepreneurial scenario and asked to perform an idea generation task. The task was designed to support external validity and to even out domain-specific knowledge. Half of the participants knowingly had access to ten random ideas generated by one creative AI system. This system was powered by a cutting-edge natural language processing solution named *GPT-3*. All participants were exposed to the same software interface to test only the indirect effect of the creative AI-generated stimuli on entrepreneurial creativity. Participants then answered a survey to measure control variables. Ideas generated by participants were evaluated relatively to each other by multiple expert judges to measure outcome variables. These judges had diverse profiles. Cognitive flexibility was operationalized by measuring the number of semantic categories for which each participant generated at least one idea. Semantic categories were identified through qualitative coding. A regression-based mediation

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for categorical variables was applied in order to verify the conceptual model. Results partially support the conceptual framework. On the one hand, compared to unaided individuals, the use of creative AI-generated ideas did have a significant positive indirect effect on the number of creative, novel and useful ideas. On the other hand, the use of creative AI-generated ideas also had no effect on usefulness of ideas and a significant negative indirect effect on creativity and novelty of ideas. Therefore, creative AI is a double-edged sword for entrepreneurs. Through the mediating effect of cognitive flexibility, using creative AI during the production of new venture ideas leads to more high-quality ideas at the expense of the average quality of ideas. Practical implications, academic contributions for the entrepreneurship literature and future research directions are discussed.

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Keywords: Artificial intelligence, Entrepreneurial creativity, New venture creation, Idea generation, Cognitive Flexibility, Creativity support systems

Developments in the foundations of AI

A deep latent space model for network clustering with edge features

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Recently, the interaction between individuals has been significantly increased ranging from social media (Facebook, Twitter), electronic communications (email, citation) to protein-protein interaction networks. However, most of the existing graph clustering methods only focus on node features and ignore the rich information of textual edges. In this work, we propose a deep latent space model that combines a statistical model with a graph convolutional network to cluster the vertices, while simultaneously using the network structure with the text content on edges. Three simulation scenarios and numerical experiments on the Enron email network demonstrate the effectiveness of our methodology and allow to compare with the state-of-the-art methods.

Keywords: Network clustering, Graph convolutional network, Latent space model, Textual edges.

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Class-agnostic Object Detection and Tracking

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Recently, Trackformer has been proposed to track objects in videos based on transformer. However, this tracking mechanism tends to hurt the implicit queries selection made by the decoder. Moreover, the employed training procedure relies on a specific class set and can be slow to train on new classes. However, robotics applications required models able to track any type of object in various scenarios quickly.
To address this challenge, we present an ongoing work with the following contribution :

- We propose a Persistent Trackformer architecture with a tracking mechanism based on iterative track queries refinement. We demonstrate that this alternative demonstrate better convergence and inference properties.

- A new spatio-temporal semi-self-supervised strategy designed to train a class agnostic object detection tracking.

- This architecture can be finetuned on various tracking tasks by learning only a liner layer on top of the tracked queries.

In the past year, multiple works in computer vision proposed to use transformer architecture to replace various components of the typical objects detection pipeline. The first one was DETR [1] based on an encoder-decoder transformer architecture with object set prediction. After this contribution, multiple improvements made the network architecture more robust and practical for concrete vision applications such as Modulated Co-Attention [4] or Deformable attention [6]. This trend of replacing CNN components with transformers continued, this time replacing the whole backbone. ViT or Swin Transformer rely solely on attention mechanisms throughout the backbone while getting SOTA results on various Image net benchmarks. In parallel, 1 major improvements were achieved using self-supervised methods in computer vision. Training processing such as SimCLR [3], Moco [5], or more recently DINO [2] demonstrated the possibility to reach SOTA results on linear classification on ImageNet without using any labels.

These works on self-supervised learning are currently applied densely through a feature map (CNN or transformer-based). In this work, we exploit the shift from entangled CNN representation to disentangled vector representation (symbols or slots) of objects to enhance current tracking capabilities.

Our contribution is two-sided. First, we propose a class agnostic tracking mechanism that

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iteratively refined the decoder state. This tracking procedure improves convergence at training and improve performance at inference time. Secondly, we proposed a new training procedure where the architecture is jointly trained on two main tasks :

- A supervised task : Object detection from various categories independently of the target class without negative sampling. Therefore, the model tend to make more proposals without shifting into one specific dataset distribution. The network is trained to detect any salient objects.

- A self-supervised task : Training with a contrastive loss within the network symbols on various image transformations using unlabeled images.
Along with the two main tasks, the network is trained to track any salient relevant objects in videos. Under this tracking framework, the contrastive loss is applied on real-world (temporal) transformation. Combining multiple object tracking datasets leads to more generic representation.

Keywords: Transformer, tracking, MOT, Robotics, self, supervised learning

Clustered Sampling: Low-Variance and Improved Representativity for Clients Selection in Federated Learning

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Federated learning (FL) is a training paradigm enabling different clients to jointly learn a global model without sharing their respective data. FL is based on estimating local client' parameters updates, and subsequently aggregating the parameters to form a global model. Communication can be a primary bottleneck for FL since wireless and other end-user internet connections operate at variable communication rates while being potentially unreliable. To reduce the number of client-server communications, in FL the server can select a subset of clients participating at every iteration. Different clients sampling approaches have been proposed [1,2], among which the most popular strategy consists in sampling a subset of clients according to a multinomial distribution (MD) where clients' probabilities correspond to their relative sample size.
It can be shown that MD sampling may lead to large variance in the clients' selection procedure, negatively impacting the convergence of FL, especially in non-iid applications. In this work we overcome this limitation by proposing *clustered sampling*, a new unbiased client sampling scheme improving MD sampling by guaranteeing smaller client selection variability, while keeping to a minimum server-clients communication. By increasing clients' representativity in the model aggregation step, clustered sampling ensures that clients with unique distributions are more likely of being sampled, leading to smoother and faster FL convergence.

Clustered sampling is a generalization of MD sampling. With MD sampling, clients are sampled with replacement from the same distribution. With clustered sampling, clients are sampled according to distinct distribution laws, each of them defining a different cluster of clients providing similar contributions to the FL aggregation.

In our work: 1) We provide sufficient conditions ensuring FL convergence to its optimum with clustered sampling, and show the theoretical benefits of clustered sampling over standard MD sampling.; 2)_ We propose an implementation of clustered sampling to aggregate clients based on the similarity between clients updates showing that, compared to MD sampling, this approach reduces the variance of clients aggregation weights, while improving the representation of the clients during each FL aggregation step. This result leads to an overall improvement of the convergence of FL.

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Through a series of experiments in non-iid and unbalanced scenarios (Appendix), we demonstrate that model aggregation through clustered sampling consistently leads to better training convergence and lower variability when compared to MD sampling. Our approach does not require any additional operation on the clients' side, and can be seamlessly integrated in standard FL implementations. Finally, clustered sampling is compatible with existing methods and technologies for privacy enhancement, and for communication reduction through model compression.

This work was accepted and presented at ICML 2021:

http://proceedings.mlr.press/v139/fraboni21a.html

The python code used for this work is available at:

https://github.com/Accenture/Labs-Federated-Learning/tree/clustered_sampling

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Keywords: federated learning, client sampling, clustered sampling, multinomial distribution, distributed learning, fair, unbiased

Co-clustering of a continuous stream of counting data with an application to pharmacovilance data

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Pharmacovigilance is a central medical discipline aiming at monitoring and detecting public health events caused by medicines and vaccines. The current expert detection of safety signals is incomplete due to the massive workload it represents. We investigate here an automatic method for safety signal detection from adverse drug reactions (ADRs) data. Thus, this work focuses on the co-clustering of a continuous stream of counting data with an application to pharmacovigilance. The main goal of the generative model we introduce, named stream-dLBM, is the real-time detection of atypical behaviors or unexpected patterns in the spontaneous reports received by the RCPV (Regional Center of Pharmacovigilance). Being the standard (binary) latent block model (Keribin et al., 2010) the cornerstone of our approach, in more detail, the proposed method is an extension of the recent dynamic LBM (dLBM, Marchello et al., 2021), which performs dynamic co-clustering in a retrospective framework. Stream-dLBM is conceived such that rows and columns in dynamic counting matrices are allowed to change the clusters membership in time, thus allowing one to detect temporal breaking points in the signals. To model the cluster memberships of drugs and adversarial effects, we assumed the presence of two time-dependent multinomial latent variables, whose mixing proportions are modeled through systems of ordinary differential equations. Fig. 1 shows a graphical representation of streamdLBM. Since a direct maximization of the likelihood is not computationally feasible in the co-clustering framework, in order to handle the model inference, we rely on the variational-EM (VEM) algorithm. Our goal is to maximize the lower bound with respect to the variational distribution of the two latent variables and the model parameter . In particular, in the E-Step the model parameters are fixed and we maximize the lower bound of the likelihood with respect to the variational distribution and in the M-step the variational distribution is held fixed while the lower bound is maximized with respect to the model parameter.

Keywords: Co, clustering, pharmacovigilance, latent block model, stream of data, VEM algorithm

*Speaker

Combining Machine Training Algorithms and Multiple Criteria Decision Making: An Application to Digit Classification with Multiple Datasets

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Machine Training is the most important stage during the Machine Learning process. In the case of labeled data and supervised learning, machine training consists in minimizing the data fitting error subject to different constraints. In an abstract setting, this can be formulated as a multiplecriteria optimization model in which each criterion measures the distance between the output associated with a specific input and its label. We provide stability results of the efficient solutions with respect to perturbations of input and output data. We then extend the same approach to the case of machine training with multiple datasets. This is a relevant problem to reduce the bias due to the choice of a specific training set. We propose ascalarization approach to implement this model and numerical experimentsin digit classification using MNIST data. We have formulated the machine training model as a vector-valued optimization problem in which each criterion measures the distance between the output value associated with an input value and its label. We have proved stability results for this problem. A further extension includes the notion of sparsity: the role played by this term is twofold. From one side, itis a measure of the rule complexity. From another one, it can be used as regularization term. We have then considered the case of multiple datasets. In this case, the training can be split over each dataset simultaneusly and this leads to an extended multicriteria setting. We have applied this model to the case of a multilayer perceptron via scalarization approach. Our numerical simulation shows that the adoption of multicriteria techniques can not only provide a general framework to contextualize the machine training with multiple datasets but it can also provide a better accuracy and performance if the right choice of the weights is implemented.

Keywords: Artificial Intelligence, Machine Learning, Multiple Criteria

*Speaker

Explainable AI for automated decision-making in business

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Machine Learning is increasingly being leveraged in business processes to make automated decisions. Nevertheless, a decision is rarely made by a standalone machine learning model, but is rather the result of an orchestration of predictive models, each predicting key quantities for the problem at hand, which are then combined through decision rules to produce the final decision. For example, a mobile phone company aiming to reduce customer churn would use machine learning to predict churn risk and rank potential retention offers, and then apply eligibility rules and other policies to decide whether a retention offer is worth proposing to a certain customer and, if so, which one. Applying decision rules on top of machine learning-based predictions or classifications is typically performed by companies to deliver better conformance, adaptability, and transparency.

Interpretability is a pressing question in these situations. In the example above, it is fundamental for the sales representative to know, even roughly, why a decision was made. It is also crucial to have explanations that refer to the input data, so that the customer can understand them. Indeed, it may not be informative to provide explanation to the user by showing her some internal values predicted with machine learning and indeed this may soon became a legal requirement. While the field of interpretable machine learning is full of open challenges in itself, when trying to explain a decision that relies on both business rules and multiple machine learning models, a number of additional challenges arise. First, the business rules surrounding the models represent non-linearities that cause problems for attribution-based interpretability methods like LIME[Ribeiro et al., 2016] and SHAP [Lundberg and Lee, 2017]. Second, the already transparent business rules represent knowledge that unless exploited will causeproblems

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for sampling-based explanation methods [Jan et al., 2020]. Third, machine learning models with overlapping features will produce conflicting explanation weights. As a result, applying current methods to these real-world decision systems produce unreliable and brittle explanations. In this configuration, there is knowledge that we can exploit to make our explanations processaware [Jan et al., 2020]. We know which variables are involved in the decision policy and we know its rules. It is worth to exploit this information instead of treating the whole system as a black-box and being completely model-agnostic.
In this paper, we present SMACE - *Semi-Model-Agnostic Contextual Explainer*, a new interpretability method that combines a geometric approach inspired by Alvarez [2004] (for business rules) with existing interpretability solutions (for machine learning models) to generate feature importance based explanations. Specifically, SMACE provides two levels of explanation, for the different users involved in the decision-making process. The first level, which is useful for the business user, must provide a ranking of importance for all the variables used, whether they are input attributes or values calculated in-house. This is useful, for example, to the sales representative, who has access to and knowledge of company policies. By interpreting the process, the business user can explain, modify, override or validate the specific decision. The second level is necessary for the end customer. She does not have access to the internal policy rules, nor to the way in which decision-making processes are managed. It therefore requires explanations based solely on information that she is aware of, i.e., input features, such as her personal details or service usage values. We show that while LIME and SHAP produce poor results when applied to such a decision system, SMACE provides intuitive feature ranking, tailored to business needs.

Keywords: Machine learning, Explainable AI, Interpretability, business rules

Federated Multi-Task Learning under a Mixture of Distributions

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The increasing size of data generated by smartphones and IoT devices motivated the development of Federated Learning (FL) [1], a framework for on-device collaborative training of machine learning models. First efforts in FL focused on learning a single global model with good average performance across clients. However the existence of such a global model suited for all clients is at odds with the statistical heterogeneity observed across different clients. Indeed, clients can have non-iid data and varying preferences. Consider for example a language modeling task: given the sequence of tokens "I love eating" the next word can be arbitrarily different from one client to another. Thus, having personalized models for each client is a necessity in many FL applications.

A naive approach for FL personalization is learning first a global model and then fine-tuning its parameters at each client via a few iterations of stochastic gradient descent. In this case, the global model plays the role of a meta-model to be used as initialization for few-shot adaptation at each client. An alternative approach is to jointly train a global model and one local model per client and then let each client build a personalized model by interpolating them [2]. However, if local distributions are far from the average distribution, a relevant global model does not exist and this approach boils down to every client learning only on its own local data. Clustered FL [3] addresses the potential lack of a global model by assuming that clients can be partitioned into several clusters. Clients belonging to the same cluster share the same optimal model, but those models can be arbitrarily different across clusters. The Clustered FL assumption is also quite limiting, as no knowledge transfer is possible across clusters. Multi-Task Learning (MTL) [4] has recently emerged as an alternative approach to learn personalized models in the federated setting and allows for more nuanced relations among clients' models. MTL approaches can learn personalized models by formulating an opportune penalized optimization problem. The penalization term can capture complex relations among personalized models, but eschews clear statistical assumptions about local data distributions.

Overall, although current personalization approaches can lead to superior empirical performance in comparison to a shared global model or individually trained local models, it is still not well understood whether and under which conditions clients are guaranteed to benefit from collaboration.

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In this work, we first show that federated learning is impossible without assumptions on local data distributions. Motivated by this negative result, we formulate a general and flexible assumption: the data distribution of each client is a mixture of M underlying distributions. The proposed formulation has the advantage that each client can benefit from knowledge distilled from all other clients' datasets (even if any two clients can be arbitrarily different from each other). We also show that this assumption encompasses most of the personalized FL approaches proposed in the literature.

In our framework, a personalized model is a linear combination of M shared component models. All clients jointly learn the M components, while each client learns its personalized mixture weights. We show that federated EM-like algorithms can be used for training. In particular, we propose FedEM and D-FedEM for the client-server and the fully decentralized settings, respectively, and we prove convergence guarantees. Our approach also provides a principled and efficient way to infer personalized models for clients unseen at training time. Our algorithms can easily be adapted to solve more general problems in a novel framework, which can be seen as a federated extension of the centralized surrogate optimization approach in [5]. To the best of our knowledge, our paper is the first work to propose federated surrogate optimization algorithms with convergence guarantees.

Through extensive experiments on FL benchmark datasets, we show that our approach generally yields models that 1) are on average more accurate, 2) are fairer across clients, and 3) generalize better to unseen clients than state-of-the-art personalized and non-personalized FL approaches.

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Keywords: Federated Learning, multi, task learning, personalized models, expectation, maximization

Finetunning and evaluation of the constraint-based NLG models

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The importance of the Natural Language Generation (NLG) for the textual data augmentation cannot be over-estimated, especially when it comes to the data with high legal restrictions, such as medical reports. However, the development of the efficient NLG models relies on the application of the relevant benchmarks, measuring the quality of the generated text to the golden human standard and in relation to other models performing similar tasks. The GEM benchmark initiative [1] proposed a collaborative approach in tackling a large subject of the NLG benchmarking, resulting in shared task and workshop contributions at ACL 2021. As participants of the shared task [2], we explored the usefulness of the CommonGen task for the text, generated under constraints, using the models with a hybrid POINTER architecture, proposed in 2020 [3]. The choice of the architecture was made in regards of compatibility between the input and output parameters with the CommonGen dataset composition, since the models with the POINTER architecture accept a set of keywords as an input, generating a text with the provided constraints, while CommonGen is designed to measure a common sense reasoning capacities of generative models given a set of concepts [4].

The research performed for the shared GEM task comprised micro, marco and baseline comparison levels. The micro level implied the finetunning of the POINTER base model, finetunned on a CommonGen dataset. Two opposite decoding strategies were applied to render the model output, in order to explore the edge performance with the creative and rigid sets of sampling parameters. The micro level also contained the metrics output comparison with the utterances of the CommonGen dataset. The metrics selection was made in accordance to the data available for comparison within the GEM benchmark and comprised n-gram based metrics (ROUGE, BLEU, NIST, METEOR), neural based metrics (BLEURT, BERTscore, NUBIA) and diversity metrics (MSTTR, Distict, Unique, Entropy).

On the macro level, the CommonGen task evaluation is made on two other POINTER models, which were finetuned on the Yelp restaurant review dataset and the News dataset accordingly. We also made a zero-shot test on non-finetuned model. We discovered, that the size of the finetuning dataset is directly related to the BLEURT metric result – News dataset is more than twice bigger than the Yelp dataset, while the Yelp dataset is twice bigger than the CommonGen, therefore, the BLEURT score difference between these three finetuned models is precisely 0.2, regardless of the sampling method. A zero-shot inference with the use of the rigid set of the sampling parameters gave the best result. We also indicate the minimum and the maximum BLEURT value achieved per model, explaining its mean value – we see that the quality of text received with the model finetuned on CommonGen dataset may be as good as the text,

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generated with the Yelp model, however, it may generate worse text examples as well, which impacts its final mean BLEURT score. This is important to note, as with the application of the corresponding metric threshold, a good quality text data augmentation may be achieved with more economic finetunned model.

The very last comparison was made regarding the baselines, provided on the GEM benchmark site, to compare how well the hybrid insertion-based transformer competes with the pure transformer architecture. We discovered, that while being less competitive with baseline models in regards of the lexical n-gram based metrics, the POINTER architecture is able to produce the models that have comparable or significantly better semantic, fairness and diversity metrics, compared to the baseline models, with much less of pretraining data used.

Therefore, the experiment has confirmed the usefulness of the CommonGen task from the GEM benchmark for evaluating the text, generated under lexical constraints, giving the insight to a series of applicable in practice assumptions for the textual data augmentation.

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Keywords: constrained text generation, POINTER architecture, NLG evaluation, GEM benchmark, CommonGen task, ACL shared task

Multi-view Clustering for Hate Speech and Target Community Detection on Social Media

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Social media are often exploited and misused to spread content that can be degrading, abusive, or otherwise harmful to people. An important and elusive form of such language is hateful speech: content that mocks or discriminates against a person or group based on specific characteristics such as color, ethnicity, gender, sexual orientation, nationality, religion, or other characteristics. Over the last decade, the preoccupation for the use of electronic means of communication as a tool to convey hate, racist and xenophobic contents tremendously increased, and a large number of computational methods involving Natural Language Processing (NLP) and machine learning have been proposed for automated online hate speech detection (Schmidt and Wiegand, 2017). Most of the prior works have mainly considered the task as a binary classification problem seeking to distinguish hate and non-hate speech. However recent works have highlighted the importance to consider the different nuances in hate speech to develop tools able to respond efficiently to harmful content expressed toward targeted communities (Fortuna and Nunes, 2018).
Whilst community detection has been successfully applied on Twitter data to facilitate insight into society at large (e.g. analysis of hot topics and societal trends for marketing or political purposes), the role of social networks in identifying hate-related communities is not well investigated. Through the use of community detection algorithms, prior works have demonstrated the benefit of applying these techniques to discover meaningful units of organization leading to uncovering new insights into the structure and function of the whole network under study. As a part of the proposed talk, we plan to introduce a novel pipeline aiming at automatically grouping tweets related to the same hate classes and hence unveil automatically target communities of hate speech messages on Twitter. Based on the latest advances in Multi-view Clustering (MvC) (José-García et al., 2021), the main novelty of the proposed unsupervised method lies in the exploitation of complementary and consensual information derived from multiple dataviews. To derive data views reflecting hateful content, we exploit two kinds of textual features aiming at extracting linguistic information at the sentence and sentiment levels: (1) sentence vector-based features consisting of sentence embedding representations encoded using a state-of-the-art multilingual pre-trained model; and (2) sentiment features extracted from two multilingual affect lexicons.

Experiments conducted on both the French and the English versions of the multilingual hate speech dataset (MLMA) (Ousidhoum et al., 2019) show that the simultaneous clustering of

*Speaker

multiple data views improves the clustering performance when compared to state-of-the-art clustering methods (K-Means and Spectral Clustering) based on a single feature set on both languages. Indeed, the use of the MvC algorithm combined with multiple data views results in a more accurate description of the data and a more robust partitioning.

To the best of our knowledge, this is the first approach based on multi-view clustering applied to the problem of hate speech detection. More precisely, our findings contribute to the design and the implementation of effective methods to monitor and fight online hate speech, with the twofold goal of preserving the freedom of expression of individuals, and at the same time, protecting potential victims online from discrimination, dehumanization, and incitement to violence. Furthermore, since our method can be applied to a wide array of online platforms, this work may help to inform the direction of future research in this area.

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Keywords: social media, natural language processing, hate speech detection, multi, view clustering

Spiking Neural Networks for Time Series Forecasting

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The advent of Deep Neural Network models (DNN) has certainly been one of the major advances in recent decades. Their achievements have taken them as the models of choice in virtually all areas of machine learning. However, their unprecedented performance comes at the cost of considerable computational complexity and energy consumption. In contrast, the Spiking Neural Networks (SSN) offer alternatives to these models promising much lower computational complexities and reduced power budget. SNN have achieved excellent performances in classification tasks for images or sounds for instance. Their explicit time dependence position them as natural models to deal with time series processing. It turns out that, in the current scientific or technical literature, SNN are mainly used in time series processing for their classification capacities. We present a work in progress in which the performance of SNNs and DNNs are compared for time series forecasting tasks. In order to obtain relevant bases for comparison, we address simple cases with a particular focus on ARMA time series forecasting for which many results can be derived analytically.

Keywords: Spiking Neural Networks, Time Series forecasting

*Speaker

The Stochastic block model meets the embedded topic model

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The increase in the size of the networks, such as social media, stresses the need for efficient clustering methods to keep the data humanly understandable. Moreover, many networks come with textual data, e.g emails, co-authorship networks or free responses from questionnaires. This type of data can be difficult to incorporate into a model-based clustering method. In this paper, we consider a graph for which two nodes are linked if and only if they share textual data. We introduce the embedded topics for the stochastic block model (ETSBM) in order to simultaneously perform clustering on the nodes while modelling the topics exchanged between the different clusters. The model is based on the stochastic topic block model (STBM). We replaced the topic model block, based on the latent Dirichlet allocation (LDA) with the embedded topic model (ETM) to benefit both from the flexible variational distribution and the possibility to use pre-trained embeddings. A variational-Bayes expectation-maximization algorithm (VBEM) combined with a stochastic gradient descent (SGD) is used to perform the inference. The model is evaluated both on simulated data and on a real-world dataset.

Keywords: embeddings, topic models, graph clustering, generative models, variational, Bayes expectation, maximization

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Towards safe deep semi-supervised learning

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Semi supervised learning (SSL) provides an effective means of leveraging unlabeled data to improve a model's performance. Even if the domain received a considerable amount of attention in the past years, proposed methods lay on assumptions difficult to test in practice and do not come with theoretical guarantees on the safeness of using the method. We propose a modification of the SSL framework applicable in various scenarios and provide theoretical guarantees on the safeness of the method even without strong assumptions on the data distribution. We test the safe method proposed to Pseudo-label and show it can improve deep semi-supervised learning techniques in various settings. We also show the method does not degrade the model's performance in ill situations.

Keywords: Semi supervised learning, Unlabeled data, Scoring rules, Pseudo, labeling, Consistency

*Speaker

Underwater Target Classification with Explainable Deep Learning Architecture

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With increasing number of sensors on passive acoustic antennas, the ability for submariners to analyze all received energetic detections is being challenged. In that respect, deep learning, with its recent advances, has reemerged as a possibility to alleviate the need for constant human operator monitoring. However, due to its complexity, underwater target classification is a rather challenging task. Indeed, while deep learning classification is often used in high signal-to-noise ratio conditions, such as speech recognition or environmental sound classification, classification in underwater environment must deal with substantial levels of ambient noises, partially hiding ship's signal. Furthermore, in such safety-critical applications, it is out of the question to use a black box algorithm like conventional neural networks. Marine operators need satisfactory explanations for classification.

Explainability can concern interpreting the reason behind a decision through various visualization methods, but we would rather focus on structural explainability. Indeed, an internal mathematical structure that can be interpreted could be considered as a suitable form of explainability in our case. Hence, we propose to develop deep architectures whose decision process can be interpreted by marine operators through familiar imposed structures such as architectures inspired from optimal signal detectors. For this purpose, we exploit a realistic acoustic model of propeller acoustic waveform that allows us to work in a controlled setting calculate the optimal Bayes detector. Under suitable assumptions, the risk of a deep neural network converges towards the minimum risk attained by the Bayes detector. However, there is no result on the convergence of the neural network architecture itself towards the Bayes detector structure. This presentation is interested in this functional convergence that guarantees that the structure of the deep neural network matches the structure of the Bayes detector.

In this presentation, we define a class of Bayes explainable neural networks whose structure matches the Bayes detector structure. We then establish that the approximation error of this class is as small as desired. Finally, we show that our class of neural networks can be easily implemented as a convolutional neural network with a specific layer organization.

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Keywords: Underwater acoustic signal, Explainable Deep Learning, Bayes detection, CNN, Approximation

"Don't discuss": Investigating Semantic and Argumentative Features for Supervised Propagandist Message Detection and Classification

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One of the mechanisms through which disinformation is spreading online, in particular through social media, is by employing propaganda techniques. These include specific rhetorical and psychological strategies, ranging from leveraging on emotions to exploiting logical fallacies. In this work, our goal is to push forward research on propaganda detection based on text analysis, given the crucial role these methods may play to address this main societal issue. More precisely, we propose a supervised approach to classify textual snippets both as propaganda messages and according to the precise applied propaganda technique, as well as a detailed linguistic analysis of the features characterising propaganda information in text (e.g., semantic, sentiment and argumentation features). Extensive experiments conducted on two available propagandist resources (i.e., NLP4IF'19 and SemEval'20-Task 11 datasets) show that the proposed approach, leveraging different language models and the investigated linguistic features, achieves very promising results on propaganda classification, both at sentence- and at fragment-level. Finally, we will analyse and discuss the main propaganda technques used in political debates and how to automatically identify such fallacies.

Keywords: Propaganda detection, political debates, argumentation, Natural Language Processing, Reasoning

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