BECAS JAE INTRO ICU
PROPUESTAS DE PROYECTOS CONEXIÓN-CSIC AIHUB

JAEINTROAIHUB-2

Título: Machine learning optimization of high temperature superconducting films prepared by drop-on-demand inkjet printing
Tutor/es: Albert Queraltó and Teresa Puig
Centro: Instituto de Ciencias de los Materiales de Barcelona, ICMAB http://www.icmab.es
Dirección: Campus de la Universitat Autònoma de Barcelona 08193 Bellaterra, Catalunya, Espanya
Descripción: High-throughput experimental (HTE) methods are becoming more important in the field of materials science, representing a turning point in the accelerated discovery, development and optimization of materials. The versatility of drop-on-demand inkjet printing allows its implementation with HTE strategies for combinatorial chemistry studies by fabricating complex-shape test compositional gradient films, suitable for parallel characterization of morphological, structural and functional properties. This project will explore such approach together with advanced characterization techniques and the use of machine learning algorithms in order to push forward the optimization in growth and performance of high temperature REBCO superconducting films, prepared following the recently developed transient-liquid assisted growth chemical solution deposition (TLAG-CSD) route where ultrafast growth rates, above 100 nm/s, are achieved. Altogether, the main aim is to promote the use of high temperature superconductors to reduce the negative impact of fossil fuels and enable the full transition to renewable energy alternatives.

JAEIntroAIHUB-3

Título: Redes neuronales de láseres estocásticos
Tutor/es: Cefe López
Centro: Grupo de Cristales Fotónicos, Instituto de Ciencia de Materiales de Madrid (luxrerum.org)
Dirección: C/ Sor Juana Inés de la Cruz 2, 28049, Madrid
Descripción: La mayoría de la computación clásica se lleva a cabo en procesadores de silicio, incluso si se trata de algoritmos basados en inteligencia artificial, aquellos que se inspiran o simulan el funcionamiento del cerebro. Sin embargo, la inteligencia artificial requiere nuevas arquitecturas fundamentalmente diferentes a los procesadores de silicio clásicos. Los láseres estocásticos son dispositivos fotónicos emisores de luz fáciles de fabricar y que pueden ser integrados en una plataforma material formando una red neuronal. El carácter intrínsecamente no lineal de los láseres dota dicha red de capacidad computacional requerida para encarnar inteligencia artificial. La emisión omnidireccional que facilita que cada laser se acopla a varios y la naturaleza aleatoria de estos dispositivos reduce las demandas de precisión en la fabricación y mejora las posibilidades de acoplamiento mutuo. Los dispositivos se fabrican practicando agujeros microscópicos (mediante técnicas de ablación láser) en una película de bio-polímero con colorante y bombeando ópticamente el segmento que los une. Estos agujeros hacen las veces de espejos y, por su rugosidad natural, actúan como centros de difusión. Como cada agujero puede pertenecer a varios resonadores, estos pueden acoplarse formando estrellas, cadenas o cualquier configuración imaginable. Este plan permitirá aprender a fabricar redes neuronales elementales y estudiar el acoplamiento en múltiples configuraciones. La interdisciplinariedad del proyecto permite integrar químicos o bioquímicos (producción de materiales activos biocompatibles), físicos e ingenieros (preparación del sistema fotónico) e incluso informáticos (estudio del funcionamiento mediante algoritmos de inteligencia artificial).

JAEINTROAIHUB-4

Título: Development of new materials for neuromorphic computing
Tutor/es: Ignasi Fina
Centro: Institut de Ciència de Materials de Barcelona (ICMAB-CSIC)
Dirección: Carrer dels Til·lers s/n Campus UAB, Bellaterra 08193; Cataluña

Descripción: Computing as we know it today is doomed to disappear. New paradigms of quantum computing or emulating the human brain are being developed, so new materials are needed. Among the research being carried out for the development of materials to be integrated into neuromorphic computing devices are ferroelectric materials. The information in this type of material can be stored in the form of an electric charge state. This state can be "read" by resistance measures. The relationship between the state of electric charge and resistance is given by the band diagram of the material. It is for this reason that research becomes essential. The aim of the project is to investigate the band diagram in ultra-thin layers (<5 nm) of potentially industrially integrable ferroelectric materials. The student will perform tasks and develop activities in the field of material growth. This includes structural, morphological, and electrical characterization. The project also includes computing tasks. Finally, the student will train skills in data analysis, summary generation and presentation of results. The PhD will integrate a group with students and researchers with diverse expertise and aims. The project will also be integrated in in-going collaborations with MIT (USA), University of Cambridge (UK), and others. The thesis will be supervised by Ignasi Fina (https://scholar.google.com/citations?user=e0qqw3YAAAAJ&hl=ca) with an intensive production and several on-going projects regarding the topic during the last years.

JAEINTROAIHUB-5

Título: Cycle-GANs: generating artificial images for supervised galaxy classification deep learning algorithms
Tutor/es: Helena Domínguez Sánchez
Centro: Machine Learning and Galaxy Evolution, Institute of Space Sciences (ICE-CSIC)
Dirección: Carrer de Can Magrans, 08193 Cerdanyola del Vallès, Barcelona
Descripción: Supervised deep learning (DL) algorithms have been demonstrated to be extremely successful and efficient for classifying large number of galaxy images (e.g., Domínguez Sánchez et al. 2018, 2019). However, these supervised algorithms need of large labelled training sets coming from the same data domain as the sample they aim to be applied to. Brand new surveys would require of a visual inspection of a large number of galaxies to construct catalogues which can serve as training, but this step is very time consuming. This limitation can be overcome by generating artificial data by means of a Cycle GAN, which is an image "translator". A generative adversarial network (GAN, Goodfellow et al. 2014) is a class of machine learning framework which learns to generate new data with the same statistics as the training set by combining two neural networks which contest with each other in a game (in the form of a zero-sum game, where one agent's gain is another agent's loss). A cycle GAN combines two generators and two discriminators to convert an image from data domain A into its corresponding version from data domain B. In particular, in this project we will convert SDSS images, with available morphological labels, into their DES counterparts. Then we will test the ability of DL models trained with the mock DES galaxies and the SDSS labels to properly classify original DES images. If successful, this approach will be a fundamental shortcut for classifying galaxy images in future Big Data surveys such as Euclid or LSST.

JAEINTROAIHUB-6

Título: Discovering galaxy formation channels with unsupervised learning
Tutor/es: Helena Domínguez Sánchez
Centro: Machine Learning and Galaxy Evolution, Institute of Space Sciences (ICE-CSIC)
Dirección: Carrer de Can Magrans, 08193 Cerdanyola del Vallès, Barcelona
Descripción: Galaxies show a very complex and diverse evolutionary paths for which we do not have yet a comprehensive picture. One of the main reasons is that their evolution is so slow in time that we can only study galaxies at the moment of the observations. Simulations are of great help to overcome that issue. In particular, the IllustrisTNG project is a suite of state-of-the-art cosmological galaxy formation simulations. Each simulation in IllustrisTNG evolves a large swath of a mock Universe from soon after the Big-Bang until the present day while taking into account a wide range of physical processes that drive galaxy formation. The simulations can be used to study a broad range of topics surrounding how the Universe — and the galaxies within it — evolved over time. Combining the TNG50 simulations with unsupervised learning algorithms, will allow us to find underlying patrons in the intricate pathways followed by galaxies up to the

present day. Unsupervised learning is a rather unexplored tool in astronomy but with an incredible potential to help us find the unknown and unexpected.

JAEINTROAIHUB- 7

Título: Desarrollo de un app para el apoyo a la detección temprana de Alzheimer con el uso de Inteligencia Artificial
Tutor/es: Verónica Sanz
Centro: SOM, IFIC-CSIC
Dirección: Catedrátic José Beltrán Martinez, 2, 46980 Paterna, Valencia
Descripción: En este proyecto proponemos 1.) Desarrollar un algoritmo que, basado en una imagen de un dibujo elaborado por el paciente, establezca una probabilidad de presencia de Alzheimer, 2.) Basado en este algoritmo, desarrollar un app capaz de correr en un dispositivo móvil, que transforme una foto del dibujo en una probabilidad de Alzheimer. Y 3.) Establecer, trabajando con responsables sanitarios del Hospital Clínico de Valencia, un mecanismo de validación de los resultados que siente las bases para una herramienta de uso
más generalizado.

JAEINTROAIHUB- 8

Título: Generative models and Bayesian optimization for de novo design with applications to CB2R ligands discovery.
Tutor/es: Roi Naveiro, roi.naveiro@icmat.es, Nuria Campillo, nuria.campillo@csic.es
Centro: DataLab Group, Instituto de Ciencias Matemáticas (ICMAT-CSIC)
Dirección: Campus Cantoblanco UAM, C/ Nicolás Cabrera, 13-15, 28049 Madrid, España
Descripción: Drug design with specific properties entails high research and development costs. Therefore prediction of such properties based on relevant features is essential in such activity. From a computational point of view, this entails two core activities: the identification of drug like molecules that serve as potential candidates and the evaluation of these candidates through some performance measure. The usual approach to identify promising candidates goes as follows: chemical experts identify a set of possible candidates, and quantitative structure–activity relationship models (QSAR models, typically machine learning ones) are built to screen the candidates and select the most promising ones which will be later synthesized and biologically evaluated. One of the goals of the project is to develop methodsto identify promising molecules automatically, reducing the intervention of chemical experts. For that, generative models (such as variational autoencoders) capable of creating drug-like molecules will be trained and optimized in order to generate molecules with optimal performance. Bayesian optimization methods will be used for optimization purposes. As underlying case study, we shall consider the case of cannabinoid CB2 receptors. These have been instrumental in the treatment of numerous diseases and lack the negative effects of CB1 receptors but their development is extremely costly. On the whole, we aim at developing a decision theoretic QSAR approach to CB2 receptor ligands design based on AI predictive models and a utility model which takes into account the costs and benefits associated with research and development in drug discovery. Knowledge of machine learning and statistics is essential. Working knowledge of Python and/or R required. Knowledge of TensorFlow and/or PyTorch is recommended. No chemical knowledge is required.

JAEINTROAIHUB- 9

Título: Modular deep learning architectures for the classification of time series
Tutor/es: Massimiliano Zanin
Centro: Complex Systems, IFISC (CSIC-UIB)
Dirección: Universidad de las Islas Baleares, Palma de Mallorca
Descripción: Within the larger field of Deep Learning, many models have been proposed to tackle the problem of classifying time series – e.g. to be able to detect the health condition of a patient given a time series representing some bodily observable. These are usually adapted from other problems, mostly image classification, and some of the most popular and effective solutions include Fully Convolutional Neural Network (FCN), Multi-Channel Deep Convolutional Neural Networks (MCDCNN) or Residual

network (ResNet). Notably, these models are based on different configurations of a small set of basic computational elements, e.g. convolutional or pooling layers. In this project we will develop a modular software library, able to train and evaluate different neural network topological structures, with the aim of 1) evaluate to what degree the performance of the model depends on the topology, and 2) whether the best topology is a function of the data under analysis. The evaluation will leverage on multiple data sets, coming from biological (brain dynamics), social (financial markets) and technological (air transport) systems. Finally, the student will have the possibility of working and getting proficient with industry-standard software libraries (TensorFlow and Keras for Python) and hardware infrastructure (in-house cluster of Nvidia GPUs).

JAEINTROAIHUB-10

Título: Digitalización inteligente para sistemas de radio cognitiva
Tutor/es: José M. de la Rosa jrosa@imse-cnm.csic.es, jrosa@us.es, www.imse-cnm.csic.es/~jrosa).
Centro: Instituto de Microelectrónica de Sevilla, IMSECNM
Dirección: Universidad de Sevilla
Descripción: La tecnología denominada radio cognitiva o CR (de Cognitive Radio) permite hacer un uso más eficiente del espectro electromagnético, modificando de forma dinámica sus parámetros de transmisión y recepción en función de la información sensada del entorno. La implementación de esta tecnología requiere, por un lado, diseñar un sistema de comunicaciones con una digitalización lo más próxima a la antena, de forma que se incremente su capacidad de programabilidad mediante software. Por otro lado, se requiere dotar al sistema de un cierto grado de inteligencia, de forma que sea capaz de establecer, de forma óptima y autónoma, las especificaciones de sus componentes en función de las condiciones del entorno (cobertura, ocupación del espectro, interferencias), estado de la batería, y consumo de energía. El proyecto en el que se enmarca el trabajo de iniciación a la investigación que se propone, tiene como objetivo fundamental el diseño de digitalizadores inteligentes para CR. Para ello, se pretenden desarrollar transceptores con una alta capacidad de adaptabilidad, de forma que sus prestaciones puedan ser controladas por algoritmos de inteligencia artificial. Aunque el proyecto abarca aspectos de todo el sistema de comunicación, el diseño físico se centra en el digitalizador como bloque esencial constituyente de los dispositivos CR-IoT. Se combinarán técnicas de digitalización de señales de radio con procesamiento de aprendizaje automático (machine learning). Para la realización del digitalizador propuesto, se diseñará un chip en una tecnología de 28nm. Durante el periodo de disfrute de su beca, el/la estudiante tendrá la oportunidad de introducirse en el mundo de la investigación en micro/nanoelectrónica mediante tareas desarrolladas en el marco del citado proyecto, que serán tutorizadas por el investigador responsable, así como por los investigadores que trabajan en el proyecto. Estas tareas de investigación se complementarán con actividades de formación que incluirán la familiarización con los equipos de computación y de laboratorio de diseño de chips. Se emplearán las tecnologías micro/nanoelectrónicas más avanzadas que se encuentran disponibles en el Instituto de Microelectrónica de Sevilla, IMSECNM (CSIC, Universidad de Sevilla). Se hará uso también del clúster de computación de alto rendimiento disponible en el IMSE-CNM, así como de entornos CAD de diseño utilizados en la industria del sector de los semiconductores, como Cadence IC Design. La caracterización experimental de los chips diseñados se llevará a cabo en los laboratorios del IMSE-CNM, equipados con instrumentos de medida de última generación. Opcionalmente se podrá compaginar también con actividades formativas recogidas en el máster universitario en Microelectrónica y en el programa de doctorado de Ciencias y Tecnologías Físicas de la Universidad de Sevilla. Además, se prevé que el/la estudiante asista a conferencias y seminarios que se organizan periódicamente en el IMSE-CNM y que son impartidos por expertos a nivel mundial en diversas materias de investigación en micro/nanoelectrónica.

JAEINTROAIHUB- 11

Título: Low-Energy AI for Always-On Edge Devices
Tutor/es: Bernabe Linares-Barranco
Centro: Instituto de Microelectrónica de Sevilla (IMSE-CNM)
Dirección: Cl Américo Vespucio, 28. Parque Científico y Tecnológico Cartuja, 41092 Sevilla
Descripción: AI has a severe problem: it consumes an enormous amount of energy. Present-day AI systems need to run on power-hungry GPU-driven data centers interconnected with the users through fast internet. This trend is unsustainable and today we know that with the present trend, by 2030 internet and data

centers will consume 20% of the world's electricity. On the other hand, the human brain consumes just 20W of power while being capable of cognitive tasks not yet mastered by man-made machines, and while continuously interacting with all body sensors and actuators. The brain uses a different technology than standard computers, which uses neurons that are over one million times slower, become defective and compute with poor precision. However, information encoding is done through population-based nervous spikes that exploit spatial sparsity and time-driven computing principles. Spiking Neural Networks (SNNs) are the third generation of Neural Networks that try to imitate such computing principles. World-wide top computer industries are presently investing strongly in the potential of SNNs, with the hope to deploy low-energy AI on portable edge devices (phones, tablets, appliances, toys, security, and surveillance). Examples are IBM with their TrueNorth chip and systems, Intel with their Loihi chip and related systems, or on the academic side the EU Flagship Project "The Human Brain Project" which has provided, among many other outputs, the SpiNNaker computer, an SNN machine capable of simulating in real-time 1-billion neurons (1% of the human brain). At IMSE, the neuromorphic group has over 25 years of experience with SNN hardware, vision sensors, and computing algorithms. We have SpiNNaker and Loihi hardware devices, as well as vision sensors that directly provide spiking output information, similar to biological retinas, ready to be processed by SNN hardware. The neuromorphic group at IMSE has participated as co-founder of spin-off companies Prophesee (www.prophesee.ai) which produces spiking retina chips (called Dynamic Vision Sensors – DVS), and GrAI-Matter-Labs (www.graimatterlabs.ai) producing SNN processing hardware. The project for the successful candidate will consist in getting familiar with SNN software for training such neural networks and apply it to camera recordings obtained from DVS cameras available at IMSE, to recognize familiar objects. Once a specific computing architecture is performing correctly using the software, it would be deployed on the SpiNNaker or Loihi computing platforms available at IMSE, running the SNN algorithm with live DVS data. Our group has experience in both: (a) computational aspects of SNNs using and creating SNN databases for machine learning training, down to (b) fully hardware aspects for SNN implementations ranging from programming FPGAs or to designing specific chips. Therefore, the project can be adapted to the candidate's preferences and prior training, emphasizing more the computational and algorithmic aspects or setting the strength onto more hardware-specific aspects. The schedule and duration of the scholarship are negotiable with the successful candidate in order to adjust them to the candidate's restrictions and preferences during the training at IMSE.

JAEINTROAIHUB-12

Título: La AI en imagen médica durante la crisis del Covid-19
Tutor/es: David Barberá-Tomás
Centro: Ingenio (CSIC-UPV)
Dirección: Ciudad Politécnica de la Innovación, Camino de Vera, s/n 46022 VALENCIA
Descripción: El proyecto consiste en crear y codificar una base de datos de artículos sobre algoritmos AI en imagen médica para la diagnosis y prognosis del Covid-19. Los 320 artículos provienen de una revisión sistemática publicada en Nature Artificial Intelligence (Roberts et al., 2021). La principal tarea del proyecto es clasificar los artículos según la procedencia de los datos de imagen médica computerizada (datos abiertos, proporcionados por un consorcio, etc.) y el tipo de algoritmo de AI emplean (deep learning, random forest, support vector machine, etc.). El proyecto se inscribe en una investigación más amplia -enmarcada dentro de las ciencias sociales- acerca de la influencia de las distintas formas de control de los datos sobre la dirección de la actividad innovadora en AI en imagen médica. Además del trabajo de clasificación de artículos, esta investigación emplea otras metodologías cualitativas (como entrevistas con desarrolladores de algoritmos o médicos) que también serán parte de las actividades de formación del solicitante durante el proyecto. Referencias:
Roberts, M., Driggs, D., Thorpe, M., Gilbey, J., Yeung, M., Ursprung, S., & Schönlieb, C. B. (2021). Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans. Nature Machine Intelligence, 3(3), 199-217.

JAEINTROAIHUB-13

Título: Modelado Cognitivo de la interferencia entre recursos en la ejecución de tareas duales
Tutor/es: M. Dolores del Castillo y J. Ignacio Serrano
Centro: Centro de Automática y Robótica (CAR), CSIC-UPM, https://g-nec.car.upm-csic.es/

Dirección: Ctra. Campo Real, km. 0,200. 28500 Arganda del Rey. Madrid
Descripción: La especie humana es capaz de llevar a cabo varias tareas simultáneamente como, por ejemplo, hablar por teléfono y cruzar una calle con semáforo. Esta habilidad descansa, fundamentalmente, en cómo se coordinan la información que se procesa y los recursos atencionales y cognitivos entre las distintas tareas. Existen diferentes teorías en la ejecución una tarea doble o dual atendiendo a si realiza en paralelo o como una alternancia de tareas o a cómo se reparten los recursos y si se produce interferencia entre ellos. La investigación en este ámbito es un medio idóneo para profundizar en los cambios de la capacidad de procesamiento durante el desarrollo infantil o para diagnosticas desórdenes cognitivos producidos por enfermedades neurológicas, además de para lograr un conocimiento mayor sobre cómo funciona el cerebro. Una herramienta para llevar a cabo esta investigación son los modelos computacionales cognitivos, que permiten simular las características conductuales y cognitivas del ser humano. El objetivo del proyecto, que se propone para esta beca, radica en la construcción de los modelos cognitivos asociados a cada una de las teorías de interferencia de recursos en la realización de una tarea dual. Cada modelo cognitivo será ejecutado en un robot físico (tipo robot de compañía). La doble tarea que llevarán a cabo se enmarcará en el paradigma cognitivo-motor y constará de una tarea con un componente cognitivo (realización de una operación aritmética) y una tarea con un componente motor (elevación de los miembros superiores hasta una determinada altura). En estos modelos se estudiarán los recursos operacionales y de información necesarios para incorporar las distintas teorías, así como las métricas para comparar el rendimiento entre modelos como el tiempo de ejecución o el porcentaje de recursos empleados, entre otras.

JAEINTROAIHUB-14

Título: Neural Sign Language Translation for Virtual Reality
Tutor/es: Xavier Giró-i-Nieto and Francesc Moreno-Noguer
Centro: RobIRI: Robot Perception and Manipulation at IRI. Institut de Robòtica i Informàtica Industrial UPC-CSIC
Dirección: Carrer de Llorens i Artigas, 4, 08028 Barcelona
Descripción: Technical advances in videoconferencing have been recently boosted thanks to the major adoption of teleworking after the global COVID-19 health crisis. However, these systems are far away from providing a realistic experience, so augmented and virtual reality solutions are being improved to provide commercial solutions in the short term. The popularization of wearable headsets to interact in virtual environments (eg. Facebook Oculus in Metaverse) also provides an opportunity to remove the communication barriers between the Deaf and Hearing communities. Some Deaf have acquired skills to understand lip-reading, but this is an additional effort prone to communication errors. On the other hand, the large majority of the Hearing community does not possess sign language skills. This research project aims at exploiting the recent advances in neural machine translation, together with the latest technologies, for virtual reality human-to-human communication. The main goal is exploring the capabilities of the Facebook Oculus 2 headset for sign language translation, that is, to recognize a continuous sequence of signs and translate them to spoken language. While Oculus 2 possesses a high precision hands tracker1, it also covers the face of the signer, where a small portion of the sign language expression occurs. The project will quantify the loss of accuracy due to the loss of these facial features on a novel dataset of 4 hours to be recorded during this project. The recording will contain the same contents of the test partition of How2Sign2, a dataset published by the Project advisors in the International Conference in Computer Vision and Pattern Recognition (CVPR) 2021, ranked #4 in the most impactful publications across science according to the Google Scholar metrics 2021. The student will work in the RobIRI: Robot Perception and Manipulation at IRI and will join a multidisciplinar team of experts in computer vision and natural language processing. The candidate should have a strong background in training deep neural networks, preferably, with the PyTorch framework. Upon reaching the project goals, a scientific publication is expected to be submitted to a major conference or journal.

JAEINTROAIHUB-15

Título: Deep Learning Bio-inspired Processing Systems for Vision Applications
Tutor/es: Luis Alejandro Camuñas Mesa
Centro: Grupo Neuromorph, Instituto de Microelectronica de Sevilla - IMSE-CNM-CSIC

Dirección: Avda. Américo Vespucio s/n. 41092 - Sevilla (Spain)
Descripción: The project for the successful candidate will consist in developing neural processing algorithms for visual recognition, focusing on software implementation in a first stage and eventually on hardware platforms. For that the following tasks are identified: (a) getting familiar with the use of DVS (Dynamic Vision Sensor) cameras available at IMSE, understanding their spike-based operation principle and obtaining several datasets under different environments, (b) development of multi-layer spiking neural networks for high-speed processing of visual information provided by DVS cameras, (c) implementation of complete neuromorphic systems with online learning capable of real-time object recognition. For hardware implementation, several platforms are available at IMSE, like SpiNNaker or Loihi computing platforms, and general purpose FPGAs or custom-made chips.

JAEINTROAIHUB-16

Título: Advancing self-supervised deep learning in graph-structured domains
Tutor/es: Mariella Dimiccoli, https://www.iri.upc.edu/staff/mdimiccoli
Centro: Instituto de Robótica e Informática Industrial, CSIC-UPC
Dirección: Carrer de Llorens i Artigas, 4, 08028 Barcelona
Descripción: During the last decade, supervised deep learning based methods have achieved impressive performance in a variety of tasks ranging from image classification to automatic language translation. However, supervised approaches require to label huge amounts of data, which is often too time-consuming or even impracticable because of data scarcity or expert knowledge requirements. To cope with this problem, self-supervised approaches have recently emerged as a new deep learning paradigm that allows to train a model on a proxy-task with pseudo-labels that automatically generated from the data themselves, without the need of manual annotations. These techniques are particularly attractive in real world scenarios and have already proven successful in many domains, e.g., vision, natural language processing, or robotics, where they may even outperform the supervised counterparts [1]. However, these developments are still limited to the Euclidean domain, hence strongly limiting their application range. Graphs are commonly used to describe the geometry of non-Euclidean structured data in a wide range of data science domains, including social networks, physical and biological systems. Yet, the development of self-supervised learning on graph-structured data remains a challenge to the current status of the research [2]. In this project, the student will join recent efforts of the group towards developing a generative approach that learns graph node representations in a self-supervised fashion, while preserving relevant graph properties. The originality and potential of our approach resides in the use of graph structure local and global properties to provide supervisory signals for the pretext task. Given the practical advantages of self-supervised learning and the fact that graph structured data is ubiquitous throughout several disciplines and real world problems, the results of this work are expected to have high impact.

JAEINTROAIHUB-17

Título: Reconstrucción de señal en experimentos de física de altas energías con Aprendizaje Automático en FPGAs y GPUs
Tutor/es: Luca Fiorini y Arantza De Oyanguren Campos
Centro: IFIC, CSIC-Universidad de Valencia, *https://webific.ific.uv.es/web/*
Dirección: Carrer del Catedrátic José Beltrán Martinez, 2, 46980 Paterna, Valencia
Descripción: Las partículas que atraviesan los detectores en los experimentos de física de altas energías producen señales que son analizadas y reconstruidas por la electrónica de adquisición de datos para determinar parámetros como su trayectoria, impulso, energía o tiempo.
En este tipo de experimentos se necesita reconstruir las señales en tiempo real con una latencia mínima y con la máxima precisión posible. Por este motivo, se desarrollarán algoritmos basados en Aprendizaje Automático profundo con aceleradores de bajo consumo de energía (FPGAs y GPUs). Se estudiará el funcionamiento de los algoritmos desarrollados y confrontará sus rendimientos con métodos clásicos.

JAEINTROAIHUB-18

Título: Convergencia de Control sin Modelo y Aprendizaje por Refuerzo en Conducción Autónoma

Tutor/es: Jorge Villagra
Centro: Centre for Automation and Robotics (CAR), https://autopia.car.upm-csic.es
Dirección: Ctra. de Campo Real, Km. 22,800. N-III La Poveda 28500 Arganda del Rey (Madrid)
Descripción: El objetivo de este proyecto es analizar si el paradigma determinista de Control sin Modelo puede convertirse en una alternativa segura a los sistemas de control basados en IA en el contexto de la conducción autónoma, aumentando su capacidad de auto-adaptación a las condiciones operativas, y preservando un comportamiento verificable.

JAEINTROAIHUB-19

Título: Quantum machine learning in the cloud
Tutor/es: Miguel C. Soriano y Roberta Zambrini
Centro: Institute for Cross-Disciplinary Physics and Complex Systems, IFISC (CSIC-UIB)
Dirección: Universidad de las Islas Baleares, Palma de Mallorca
Descripción: Quantum systems are likely to provide a computational advantage over classical systems for machine learning tasks. Currently, the most advanced hardware for quantum computing can only be operated in a few selected research centers around the world. The IBM quantum experience aims at providing remote access to a platform of superconducting qubits, where users can run their algorithms over the quantum hardware. In this project, we will investigate how to operate the IBM quantum computing platform for the processing of sequential information in the context of the machine-learning paradigm of reservoir computing. Reservoir computing is ideally suited to process time series, for instance to forecast the power demand of the electric grid or the occurrence of an earthquake. While quantum reservoir computing has already proven valuable in numerical simulations, the proper way to operate the quantum hardware remains a challenge. The candidate will be able to work in edge applications with a particular attention to the role of quantum information encoding and quantum measurement.

JAEINTROAIHUB-20

Título: Assessing the power of variational quantum classifiers and quantum extreme learning machines
Tutor/es: Gian Luca Giorgi y Roberta Zambrini
Centro: : Institute for Cross-Disciplinary Physics and Complex Systems, IFISC (CSIC-UIB)
Dirección: Universidad de las Islas Baleares, Palma de Mallorca
Descripción: One of the main classes of problems that are usually tackled through machine learning techniques is represented by data classification. In the search for quantum advantages in machine learning, classification tasks have been mainly studied recurring to quantum artificial neural networks (QANNs). Recently, the alternative route of variational quantum classifiers was also followed, showing similar performances with respect to QANNs. Within the field of artificial neural networks, reservoir computing and extreme learning machines offer the advantage of easy and fast trainability, as only the output layer of the network needs to be updated during the training phase.
Moving to the quantum realm, both techniques have already been shown to conjugate sufficiently high performances with the advantage of an exponentially large Hilbert space. While quantum reservoir computing is especially suited to solve time-dependent tasks, quantum extreme learning machines can be useful in problems as diverse as state preparation, state reconstruction, and also data classification. The main scope of this project is to build a comprehensive framework to benchmark the performance of variational quantum classifiers and quantum extreme learning machines, considering both the standard paradigm of classification of classical data and the classification of purely quantum information, such as entanglement, coherence, etc. We will also study the possibility of implementing both methods in physical systems, exploring different theoretical models and experimental platforms.

JAEINTROAIHUB-21

Título: Using artificial neural network for detecting cognitively relevant electroencephalographic events
Tutor/es: Liset Menendez de la Prida
Centro: Instituto Cajal, http://hippo-circuitlab.es/

Dirección: AVE. DOCTOR ARCE, 37 MADRID 28002 SPAIN
Descripción: Understanding brain function requires detection and manipulation of electroencephalographic events underlying cognitive processing. One example is sharp wave ripples (SWR) a type of short-lived oscillation in the 100-200 Hz range underlying memory consolidation. While spectral filters are widely used, they suffer from issues especially in conditions of poor signal-to-noise ratios and artefacts. In this project, we aim to use convolutional neural networks (CNN) to detect SWR events using supercomputer resources and separate datasets for training and validation. Preliminary data in the lab suggest a collection of suitable architectures (CNN, LSTM, etc..) and hyper-parameter combination (kernel factors, batch size, optimizers, regularizers, decay, etc..) that provide stable operation. The project will look at these results to retrain and test different CNNs in a wide range of experimental conditions to extract detailed information about performance. The project also aim to link results that will be obtained in a hackathon (https://thebraincodegames.github.io/index_en.html) aimed to identify alternatives detection strategies.

JAEINTROAIHUB-22

Título: Latent variable models for dynamic cloth representation and control
Tutor/es: Adrià Colomé Figueras, *http://www.iri.upc.edu/staff/acolome*
Centro: Institut de Robòtica i Informàtica Industrial UPC-CSIC
Dirección: Carrer de Llorens i Artigas, 4, 08028 Barcelona
Descripción: The aim of this project is to work on latent variable models to represent the dynamic behaviour of cloth garments for their robotic manipulation. In particular statistical inference based methods that can project the cloth state into a much smaller dimensional space, allowing a controller to control a more manageable space. The candidate should be familiar with robotics and statistical inference methods such as Gaussian Processes, and have a good level of mathematics and programming skills.

JAEINTROAIHUB- 23

Título: Generative Graph Convolutional Neural Networks applied to Materials Science Problems
Tutor/es: Eduardo Hernández y Jorge Bravo Abad
Centro: Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC)
Dirección: Campus de Cantoblanco (UAM) 28047 Madrid, Spain
Descripción: Over the last decade or so, Machine Learning~(ML) Techniques have found widespread applicability both in industry and science. Particularly, Deep Learning~(DL), the branch of ML that is concerned with the design, training and deployment of Artificial Neural Networks~(ANN), has demonstrated the ability to address problems that were previously intractable, such as near-human image classification, speech recognition, autonomous driving, etc. However, conventional ANNs have traditionally worked with structured data, such as a matrix of pixels in an image, while very often one is confronted with relational information that cannot be easily cast into a structured data form. This limitation has motivated the development of so-called {\em Graph Neural Networks\/}~(GNN). Graphs provide a more general way of representing interrelated data structures which is free of the constraints inherent to structured data. Typically, a graph consists of nodes, encoding items of information or node properties, and edges, representing relations between the nodes in the graph; edges themselves can encode information, such as properties of the relation between the pair of linked nodes. GNNs can take graphs as their input both to be trained and to address a number of graph-related problems, such as node classification, property prediction (at the node or graph level), etc. To the physicist, chemist or biologist, a graph is an ideal way of representing a crystal, a molecule, a disordered array of atoms (amorphous material), or even a complex bio-molecule. It is therefore not surprising that one can envisage many ways in which graph-based AI strategies may be useful in Condensed Matter and Molecular Physics, and Materials Science. In this project we aim to use {\em Graph Convolutional Neural Networks\/} to accelerate the design and theoretical analysis of crystalline, amorphous and molecular materials. Specifically, our aim is to design generative systems such as Variational Auto-Encoders (VAE) or Generative Adversarial Networks (GAN) capable of working with graphs, that can be trained on existing materials databases, and used in order to create new crystal or molecular structures with desirable structural or chemical/physical

properties. This field of research is at the cutting edge of the application of Artificial Intelligence techniques to Materials Science and Condensed Matter Physics.

JAEINTROAIHUB- 24

Título: Task-oriented semantic classification of cloth configuration states using topological and geometrical indices
Tutor/es: Julia Borras Sol y Maria Alberich-Carramiñana
Centro: Institut de Robòtica i Informàtica Industrial UPC-CSIC
Dirección: Carrer de Llorens i Artigas, 4, 08028 Barcelona
Descripción: Robotic manipulation of cloth (folding, dressing) is a highly complex task because of its infinite-dimensional shape-state space. In order to manipulate textiles with a robot as autonomously as possible, the robot needs to recognize in which state the piece of cloth is both at the high level (understanding what tasks can be applied to it) and at the low level (to know specific locations of elements that need to be manipulated). The aim of this project is to set a mathematical framework of low-complexity cloth representation in the context of its robotic manipulation (more specifically, folding or unfolding). Following preliminary results from the group, it will focus on the definition and study of topological or geometrical invariants that are able to distinguish between different folded states of a piece of cloth. The project has a duration of 9 months that will allow the student to work in close collaboration with our team to study how the defined measure can be applied to divide the infinite-dimensional cloth state space into task-dependent macro-states that simplify the understanding of the space.

JAEINTROAIHUB-25

Título: Development of perception skills for building coherent explanations during robotic manipulation
Tutor/es: Guillem Alenyà
Centro: Institut de Robòtica i Informàtica Industrial UPC-CSIC
Dirección: Carrer de Llorens i Artigas, 4, 08028 Barcelona
Descripción: In the context of the CHIST-ERA project COHERENT, we are investigating how a robotic system composed of different layers of intelligent systems can generate coherent explanations about the robot intentions behind an action or the reasons for failure. Such explanations provided not only at the end of a task but during the manipulation can ensure a more trustworthy relationship during robotic assistive tasks. In this framework, the student will work at the perception level to recognize the different scene states during a task, emphasizing on the uncertainty quantification of the recognized parameters/states. This will contribute to the explainability of the overall system. The student will work in close collaboration with the COHERENT team that is already working at the decision-making and action execution levels, with the objective of studying how to represent the knowledge learned at the different levels in a way that can be used to synthesize explanations. The project has a duration of 9 months that will allow the student to learn new techniques and to train and evaluate the solution in realistic scenarios. Collaboration with international partners and scientific publications are expected.

JAEINTROAIHUB-26

Título: Faster cost effective disaster management through active learning
Tutor/es: Jesús Cerquides Bueno
Centro: Instituto de Investigación en Inteligencia Artificial (IIIA)
Dirección: Can Planes s/n, Campus UAB 08193 Bellaterra, Barcelona
Descripción: In the CROWD4SDG EU project at IIIA-CSIC we are working together with UN and University of Geneva (among other partners) in providing AI tools that can help fulfill the Sustainable Development Goals (SDGs). One of the tools which development is planned makes use of information obtained from social media (specifically, images captured from Twitter) to help assist disaster relief when a disaster, such as a flooding, an earthquake or a volcano eruption occurs. In particular we are interested in the determination of the relevance of images and an automatic assignment of the level of damage shown in the

images, whether directly affected humans are shown and so on. This is currently done by means of human annotators. We are interested in minimizing the amount of information requested to human annotators and that decreases the time to annotation, by designing a pipeline that uses active learning, thus only requesting to the human experts those images that the machine learning algorithm is unable to annotate carefully. The student will be responsible for the evaluation of active learning strategies in this scenario, under the direction of the tutors and in close collaboration with PhD student Hafiz Firmansyah from University of Geneva.

JAEINTROAIHUB-27

Título: Forecasting hazardous geomagnetically induced currents for Spanish critical infrastructures
Tutor/es: Carlos Escobar, http://ific.uv.es/~cescobar/
Centro: Instituto de Física Corpuscular, CSIC-UPV
Dirección: Carrer del Catedrátic José Beltrán Martinez, 2, 46980 Paterna, Valencia
Descripción: In the last decades, our society has become more interdependent and complex than ever before. Local impacts can cause global issues, as the current pandemic clearly shows, affecting the health of millions of human beings. It is also highly dependent on relevant technological structures, such as communications, transport, or power distribution networks, which can be very vulnerable to the effects of Space Weather. The latter has its origin in solar activity and their associated events, such as solar flares and coronal mass ejections, which may provoke disturbances, interruptions, and even long-term damage to these technical infrastructures, with drastic social, economic and even politic impacts. However, these phenomena and their effects are not yet well understood, and their forecast is still in the early stages of development. This training project, that uses a multidisciplinary approach, aims to understand and forecast, in an unprecedented way in our country, the effects of Space Weather on the Earth's surface, and particularly the geomagnetically induced currents (GICs) that flow in long earthed conductors like communications, transport, or power transmission networks. The ultimate goal is to provide a real-time prediction of the GICs from extreme geomagnetic storms on the Spanish critical infrastructures. To achieve this, we use real-time warnings of solar storms from the ACE space probe at the L1 point in space, which leads to disruptions on Earth some 30-45 minutes later. Using deep learning and mathematical models, we study how data from ACE would translate into changes on the induced underground currents and their effects on the power grid. We will specialise on the modelling of the Iberian Peninsula, providing an early warning system.

JAEINTROAIHUB-28

Título: Aspectos éticos y sociales para una IA inclusiva y socialmente responsable
Tutor/es: Mario Toboso
Centro: Grupo de Ética Aplicada (GEA) y del Grupo Ciencia, Tecnología y Sociedad (CTS). Instituto de Filosofía IFS-CSIC
Dirección: C/Albasanz, 26-28. Madrid 28037
Descripción: El plan de trabajo que se ofrece es una aproximación a las principales cuestiones éticas y sociales que suscitan los sistemas interactivos basados en IA en ámbitos como el aprendizaje, la toma de decisiones, la agencia, la responsabilidad y la rendición de cuentas. Este plan incluye los siguientes temas:
-Detección y prevención de sesgos en las inteligencias artificiales, con especial atención a la perspectiva de género.
-Injusticia algorítmica y modificación del sentido del mérito, el esfuerzo y la justicia distributiva.
-Realidad humana temporalizada e IA.
-Interacción humano-IA con especial atención a los entornos de asistencia y cuidado.
-Responsabilidad distribuida y daño en IA.
-Privacidad, explicabilidad y auditabilidad de los algoritmos.
-Límites ecológicos de la IA.

JAEINTROAIHUB-29

Título: Uso de "reinforcement learning" para determinar el comportamiento de NPCs autónomos en entornos de simulación
Tutor/es: Jordi Sabater-Mir y Josep Lluís Arcos
Centro: Instituto de Investigación en Inteligencia Artificial, IIIA
Dirección: Can Planes s/n Campus de la UAB 08193, Bellaterra, Barcelona
Descripción: Normalmente las entidades no controladas por el usuario (NPCs) en entornos de simulación o videojuegos basan su comportamiento en "scripts" que definen como éstas deben reaccionar a los eventos del mundo dado su estado interno. Este mecanismo es muy laborioso y requiere prever todas las posibilidades de antemano por parte del diseñador del escenario. Recientemente se está empezando a utilizar "reinforcement learning" (en concreto "Deep reinforcement learning") para generar comportamiento de forma mucho más automática y obteniendo resultados mucho mejores y más robustos. Continuando el trabajo ya desarrollado en el IIIA-CSIC en este tema, el candidato trabajará en la integración de un NPC que simula un agente "curioso", y que ha sido entrenado usando "reinforcement learning", en un entorno realista de simulación de emergencias usado en el entrenamiento de bomberos. Las tareas se centrarán tanto en la mejora del proceso de aprendizaje como en la integración del NPC en el entorno 3D. Se valorará haber cursado asignaturas de Inteligencia Artificial (en especial tener conocimientos de "reinforcement learning"), tener conocimientos avanzados de programación en Python, y por último conocimiento del entorno de desarrollo de videojuegos Unity.

JAEINTROAIHUB-30

Título: Desarrollo de técnicas de aprendizaje profundo para la clasificación de memes empleados en campañas de desinformación
Tutor/es: David Arroyo Guardeño
Centro: Grupo de investigación en Criptografía y Seguridad de la Información, Instituto de Tecnologías Físicas y de la Información "Leonardo Torres Quevedo."
Dirección: C/Serrano nº 144, 2806 Madrid
Descripción: Unos de los principales retos en el ámbito cibernético viene determinado la dificultad de evaluar la fiabilidad de fuentes de información. En este proyecto se diseñará una técnica basada en aprendizaje profundo (Deep Learning) para identificar dinámicas y campañas de desinformación mediante análisis multimodal de texto y de imágenes. Para ello, se considerará como punto de partida la herramienta MsW desarrollada en el contexto del proyecto europeo TRESCA. El plan de formación a llevar a cabo se centrará en la identificación y/o creación de un conjunto de datos para el entrenamiento de redes neuronales recurrentes para la clasificación de memes usados en operaciones de información científica. El equipo de trabajo encargado de supervisar el plan de formación
forma parte tanto del proyecto TRESCA como del proyecto XAI-Disinfodemics adscrito a la temática 18 ("Desinformación, engaños y noticias falsas a través de canales públicos y privados") de la convocatoria de proyectos en líneas estratégicas 2021 de la Agencia Estatal de Investigación.

JAEINTROAIHUB-31

Título: Estrategia evolutiva para la generación automática de Redes Neuronales Convolucionales (CNN) eficientes en visión
Tutor/es: Angela Ribeiro
Centro: Grupo de Percepción Artificial, Centro de Automática y Robótica.
Dirección: Crta. Campo Real km. 0,200. Arganda del Rey. 28500 Madrid
Descripción: Las redes neuronales convolucionales (CNN) se aplican con mucho éxito en visión por computador, en concreto en tareas de detección y clasificación de objetos. Las primeras arquitecturas CNN se han obtenido a partir de elaborados procesos de diseño en el que la pericia del diseñador ha sido la clave. Así los desarrollos disponibles son fruto de años de esfuerzo e ingenio.
El grupo GPA está actualmente trabajando en la aplicación de estrategias evolutivas para la obtención de arquitecturas CNN optimizadas para entornos y tareas específicos. El estudiante se integraría en esta línea de investigación que ya ha proporcionado resultados muy interesantes. Con el trabajo propuesto, tendrá la oportunidad de acercarse a áreas de IA tan interesantes como la visión por computador, el

aprendizaje automático, el aprendizaje profundo, la optimización a través de algoritmos evolutivos; todo ello aplicado a la resolución de un problema complejo importante en la agricultura como es la detección temprana de plagas.

JAEINTROAIHUB-32

Título: Models of Complex and Spatial Networks
Tutor/es: Jordi Levy http://www.iiia.csic.es/~levy
Centro: Instituto de Investigación en Inteligencia Artificial
Dirección: Can Planes s/n Campus UAB, 08193 Bellaterra, Barcelona
Descripción: Graph structures are omnipresent in many problems, from the field of mathematics, computer science, AI, physics,... not only as networks or data structures, but also as the intrinsic structure of problems with constraints, the interaction of agents,... In recent years, complex networks or, more formally, scalefree graphs have attracted great attention. Preferential attachment has been proposed as a generic mechanism that gives rise to these types of graphs. However, it is a very partial model. In this project, we propose to study other mechanisms that give rise to these graphs, especially those that generate spatial graphs, where the nodes occupy positions in a certain space. These graphs, in addition to the variability in the arity of the nodes of scalefree graphs, present variability in the length of the arcs, fractal structures. As possible applications, we will study the influence of these structures in some classical algorithms on graphs, and their possible adaptation.

JAEINTROAIHUB-33

Título: End-to-end CNN-based model for action decision-making in Robotic cloth manipulation tasks
Tutor/es: Sergi Foix
Centro: Institut de Robòtica i Informàtica Industrial UPC-CSIC
Dirección: Carrer de Llorens i Artigas, 4, 08028 Barcelona
Descripción: At the Perception and Manipulation Laboratory, in the context of both BURG and CLOTHILDE European projects, we investigate how robots can learn, execute and understand the manipulation of garments for complex tasks such as laundry handling, bed-making, or folding and unfolding kitchen rags, among others. For such purposes, we have developed different intelligent grippers that are capable of mimicking the required human prehensile actions. Moreover, we are also developing techniques for robot transfer learning by means of kinesthetic teaching and visual human demonstration.
Under these conditions, the student will dedicate the time investigating about action decision-making algorithms based on the interpretation of force and close range visual information. Her/His research will focus on: creating a benchmark dataset based on force and visual data, and developing end-to-end CNN-based vision models for direct robot action control in manipulation of garments tasks, such as the ones listed above. The project will have a duration of 9 months that will give the student the opportunity to learn the latest Deep Learning techniques and to evaluate the solution in realistic scenarios. The student will be encouraged to collaborate with international partners and a to produce a scientific publication.