LIPADE Open PhD Positions 2021

co-funded by the ANR project:
Data Intensive Artificial Intelligence (DIAI)

Application deadline: May 19, 12noon (Paris time)
contact the advisor of the topic you are interested in well in advance!

Titre / Title:
Large temporal reasoning for Evolutionary Knowledge Graph

Résumé / Abstract:
Knowledge graphs (KG) model information in the form of entities and relationships between them. This kind of relational knowledge representation is a logic and artificial intelligence based model, called as well as ontologies. KGs provide semantically structured information that is interpretable by computers a property that is regarded as an important ingredient to build more commercial and scientific domains for instance Bio2RDF, Neurocommons and LinkedlifeData are KGs that integrate multiple sources of biomedical information. These have been used for question answering and decision support in the life sciences. Statistical Relational Learning (SRL) methods have been applied to existing KGs to learn a model that can predict new facts (edges) given existing facts (ISWC 2017, IJCAI 2018, AAAI 2020, ICML 2020). Those approaches have been used for static KGs. However, the availability of large scale event data with time stamps has given rise to dynamically evolving KGs that contain temporal information for each edge. Reasoning over time in such dynamic knowledge graphs is not yet well understood. In this thesis, we will, model deep evolutionary KG model that learns evolving entity representations over time, and provide reasoning approaches in multi-relational setting.

Contact:

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Titre / Title:

Prediction of demographic indicators from remote sensing images

Résumé / Abstract:

In a globalized context increasingly impacted by climate change, demographic studies would gain to take environmental data into account and be carried out at the transnational level. However, this is not always possible in Sub-Saharan Africa, as matching harmonized demographic and environmental data are seldom available.

In this PhD, which will be a collaboration between LIPADE and INED, we will develop methodologies using remote sensing data to predict indicators of the environment and environmental change, for demographic analysis. The large amount of data regularly acquired since 2015 (in 2019 only, Sentinel satellites from the European Space Agency produced 7.54 PiB of open-access data) can be used to produce relevant standardized indicators at the global scale.

To do so, change detection methodologies based on convolutional neural networks will be developed. Recently, this has been a strong topic through the prediction of local climate zones [3] (DiiP internship) or Corine Land Cover [4]. From a machine learning point of view, this PhD will focus on the challenges of robust indicators production from multi-modal and multi-temporal remote sensing data (in particular in the absence of a modality) and interpretable machine learning (to assess the confidence level of the indicators). These two areas of research are active in the computer vision community and have not been applied to demographic studies yet. The selected PhD candidate will illustrate the possible use of the predicted data for the contextualized analysis of demographic data collected in different parts of the subcontinent, such as demographic and health surveys and demographic surveillance sites data.

This PhD based on machine learning and statistical analysis of the predicted data addresses a fundamental challenge of our modern society through a joint effort from computer scientists and demographers.

Supervision: L. Wendling, S. Lobry, C. Kurtz (LIPADE), V. Golaz, G. Duthé (INED)

Contact:

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Titre / Title:

Exploring the tissue and its micro-environment : digital pathology

Résumé / Abstract:

The rapidly emerging field of computational pathology needs new paradigms and tools coming from computer sciences in the broadest sense of the science. Our team is developing many projects in the field including setting up international challenges (like TissueNet : detect lesions in cervical biopsies hosted by French Society of Pathology and Health Data Hub in collaboration with Driven Data). The ultimate goal is to be able to provide objective diagnosis, therapeutic response prediction and identification of new morphological features of clinical relevance within the next decade. The team has a pending patent in the field and is part of a phase 2 clinical trial for immuno-therapy as a digital companion test (starting April 2021). We are involved in the community of the French Society of Pathology and will start a PRT-K project for translational clinical research in cancerology.

In our team, we believe that the next step will rely on the integration of the computer vision/machine learning pipelines into the clinical setting. We already start to get a good deal of annotated WSI (gigapixel whole slide images 'WSI' for each patient/exam) by experts and collaborations with hospitals. We need to go the next step right now :

- as a data science playground, we need to explore deep learning architectures to perform seamless exploration and valorisation of all the data annotated across various tissues and markers to propose a scaling pipeline of processing and sharing of data among researchers and clinicians (publication submitted at MICCAI 2021);

- the integration with genomic data will also be of utmost importance in the coming decade either to validate theory in life sciences based on the observation of tumoral micro-environment or to predict genomic class based on phenotypic observation at the tissue level (publication submitted in our team in Journal of Hepathology);

- how to integrate these paradigms (for physicians) into the concept of the XX1st century microscope made possible with the advent of these new high-throughput high resolution scanners possibly with multiple markers [1]

[1] https://www.bizjournals.com/philadelphia/news/2021/02/16/the-time-is-now-digital-transformationbrings-pathology-into-the-21st-century.html

Contact:

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Titre / Title:

Multimodal analysis for Human Mobility problem based a Complex Network Approach

Résumé / Abstract:

Abstract

The analysis of complex networks is a very promising area of research, as evidenced by numerous research projects and works that focused on different areas. Very recently, these analyzes were generally focused on the in-depth characterization of only one aspect of the system. Therefore, a study that takes into account many informative axes and a network is lacking. In this PhD thesis, we propose to study a multimodal analysis capable of inspecting human mobility (complex network: Vehicles, Trains, Mobile applications, etc.) in several important dimensions of a system. In order to achieve this goal, we will study the variation of the constitutive parameters of changes in the behavior of the network as a whole and extract solutions for example green mobility in the smart context.

Context:

Over the recent years, cell phones have become ubiquitous thanks to major advancements in telecommunication technology. Cellular phones have turned out to be a great resource of data to analyze mobility behavior of people in metropolitan areas, as they overcome the limitations of other resources that fail to collect mobility data in a large scale. GPS, for example, provides accurate spatial data, but has two main disadvantages: device battery usage and the limitation of data collection for a certain group of people (e.g. drivers). The latter, in particular, makes the multimodal mobility study almost impossible. Cellular data on the other hand, appears to be a proper solution for the aforementioned drawbacks as it is inexpensive to collect for large-scale population with no excess of energy consumption of device. The problem with cellular phones compared to GPS is that they provide only coarse-grained mobility data at antenna level, with a varying localization error of hundred meters in densely populated cities, and within several kilometers in rural areas. In order to investigate the mobility behavior of users in choosing a transportation mode among different alternatives or even a combination of modes, the first requirement is to infer the real trajectory of users from their cellular data. In this PhD thesis, we propose a solution to this problem by designing and developing an approach that exploits cellular data for multimodal mobility study.

Related work

The analysis of human mobility (trains, vehicles, ,etc.) is known as one of the main problems faced by cities. With the growth of urban areas and metropolitan cities, the demands the monitoring of the mobility of individuals continues to increase. As different transport systems are involved in metropolitan areas, researchers are motivated to work with transport network that does not just look for a single layer the entire transport system and the relationships between the layers. In order To study the multimodal mobility of individuals, it is extremely important to use realistic data, which is another challenge in mobility studies.

Thanks to the ubiquity of mobile phones everywhere, recently network operators have been providing large-scale datasets of mobility data in form of Call Data Records (CDRs) which are automatically generated for billing purpose. CDRs, despite being an invaluable resource to extract insights about human mobility, are temporally sparse. Therefore, CDRs cannot be treated as proper data for multimodal transportation studies in cities and metropolitan areas. There is a gap between studies and a comprehensive approach to study multimodal mobility using data in urban and metropolitan areas.

One of the objectives of this thesis is to bring together all the theoretical background and the studies related to the challenges discussed in the previous section. The state of the art in different aspects of human mobility studies, mobility data and mapping algorithms. The second step ends with a correlation studies the detected gaps and claims that in the literature, there is no mapping algorithm dealing with both multimodal transportation network and also with the scalability of using mobility data in urban and metropolitan areas.

Consequently, we elaborate on modeling and building the multimodal transportation network dataset containing road, train and metro lines. While realistically representing the deterministic aspects and non-deterministic aspects of human mobility stays a challenge, there is a certain need for increased research efforts in mobility modeling. Upcoming technologies as 5G and 6G can help more accurate understanding of human mobility and researchers can simulate many environments more realistically.

One of our goals is to grow attention to the field of human mobility modeling. This later involves the collection of real-life mobility data and filtering of the data as well as the modeling of the environment and the people's behavioral decisions. A mobility model can be verified with thorough analyses of both parts with various metrics and the model needs to be calibrated during this process. As the last main process, the implementation of a human mobility simulation generates synthetic mobility traces. The traces of the mobility simulation can be used for other simulations of networks, urban transportation planning, crowd management, disaster management, and many interesting applications for better quality of life.

The PhD objective is to propose an approach to infer multimodal trajectories of smartphone users from their sparse cellular data. Student is encouraged to look at these issues to be improved and develop new techniques and protocols for Multimodal analysis for Human Mobility problem. Potential research problems can be included as new.

The aim of this doctorate research work is to:

- Make a state of art and analyze the performance, complexity and applicability of existing methods in Multimodal analysis for Human Mobility problem.
- Identify, collect and evaluate the relevant parameters that have impacts on dynamic resources quality of scalable Human Mobility parameters.
- Design a mathematical model that can take into account the effects of all these parameters (based on Inference and learning algorithms: Bayesian networks, stochastic processes, using data in urban and metropolitan areas.

Partnership: Orange company and Telecom Paris Sud Institut Polytechnique de Paris

Contact:

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Titre / Title:

An adaptive intelligent learning system for learning and recognizing events and

objects

Résumé / Abstract:

Significance and Objectives

Recent technological advancements offer the possibility of automatically collecting large amounts of information rich data from a plethora of devices characterized by different capacities and supporting different protocols. This highly heterogeneous devices, including anything from surveillance cameras to drones, is foreseen to increase significantly in the near future. However, most of the current uses of these devices in surveillance systems are neither smart nor autonomous. To this need, we propose to design and prototype a smart and autonomous intelligent physical system (IPS) for detecting and monitoring events. It will consist of a physical subsystem (PS) and a learning and processing engine (LPE). The PS consists of different types of physical sensors: fixed-location sensors, such as high-resolution PTZ (pan-tilt-zoom) cameras with embedded microphones deployed at fixed locations as surveillance cameras, and mobile sensors, such as cameras and microphones carried by mobile flying vehicles (e.g., drones). Sensors are equipped with low-level processing units to perform pre-processing and basic learning algorithms. The LPE is implemented with local cloudlets and a central cloud to perform advanced learning, reasoning, and high-precision classification.

The purpose of the physical subsystem is to act similar to a human's procedural memory and skills, allowing the detection and observation of, and orientation relative to, uncommon events. Initially, only the fixed-location sensors are active. Imagine a scenario in which the surveillance cameras at the intersections or on top of the buildings passively monitor the traffic or the parking lots. Suddenly, an explosion occurs nearby. The microphone array picks up the sound of the explosion, and approximately localizes the event. Then, the cameras focus on the identified area, looking for events that are out of place. When it is realized that the coverage of cameras may be obscured, or more detailed visual information is needed, camera drones are dispatched to collect more accurate and more detailed information. Using special classifiers with low rates of false negatives, each camera can decide whether the observed events are indeed worthy of investigation, or the cameras can communicate their observations to reach a consensus. If the (joint) decision favors the existence of an uncommon event, the cameras keep observing, and pass the observations to the higher layers for a more precise classification.

The LPE, implemented in a hybrid manner with local cloudlets and a central cloud, takes observations from multiple fixed-location sensors and attempts to classify the event. The LPE runs multiple classification algorithms in parallel, depending on its maturity. When the system is first deployed, the LPE employs a one-class classifier, which builds a database for common events. When multiple outliers are detected, in addition to an updated one-class classifier that aims to detect previously unobserved events, the LPE starts running a deep learning based multiple-class classifier. As the data collection grows to where each class encountered so far is well represented, the LPE trains more and more accurate classification algorithms, based on multi-view, multi-task, and domain adaptation deep neural networks. Data from all multiple sources and classifiers is fused to produce a high-confidence decision, and if such a high

confidence decision cannot be produced, the LPE sends a notification to a human operator. At the same time, the LPE instructs the fixed-location sensors to continue observing the event and requisitions more physical resources to cover the event if necessary. For example, one or more mobile sensors could be deployed. The human operator may choose to ignore the event altogether, or to alert the emergency response teams. The human operator can also provide high-level feedback to the LPE, praising or chastising its decision to issue an alert. If the event is eventually classified as an accident, each cloudlet decides which learned knowledge is of local interest to the covered area, and which is of general interest, and shares the generalizable knowledge with peer cloudlets. This way, each cloudlet benefits from learning from a global knowledge database and earns the ability to correctly identify and classify even events that it directly observes for the first time.

It should be noticed that the functions of both PS and LPE subsystems of the IPS are modeled after a human-specific observe-orient-decide-act (OODA) loop. For our scenario, the IPS's possible actions are restricted to intelligent allocation of resources for event observation. This is meant to minimize the intrusiveness of the IPS in people's everyday lives, as well as to maintain the IPS within widely accepted legal and ethical bounds. The action set may be expanded to cope with other anomalies such as natural disasters or terrorist attacks.

Thesis Objectives

The overarching objective of this research is to develop a complete and integrated intelligent physical system that will observe activities in environments such as urban, campus, airport or production-line environments, and learn how to recognize anomalies such as accidents, emergency situations, criminal activities, etc. The system will take actions by informing and assisting supervisors and first responders by providing them with a contextually aware characterization of the situation. In some cases, the system may also assist in and initiate actions such as traffic rerouting or directing the public to safe locations. The system will be aware of its own limitations and will be aware of its surrounding environment and its changing characteristics. The system will also be capable of lifelong learning to improve its accuracy.

The detailed objectives are:

1. To develop algorithms and strategies to deploy different types of sensors, including cameras and microphones, such that they provide sufficient and, in some cases, redundant coverage of the areas of interest. Algorithms for UAVs/drones dispatching and trajectory planning will be also developed for situations in which drones have to be used to obtain more accurate views or to track suspects.

2. To develop a framework and its associated algorithms/protocols for planning and dimensioning the sensing devices, networking links and equipment in order to achieve a robust operation that withstands sensor, link and equipment failures.

3. To develop strategies for data collection from, and exchange between, sensing devices, and lightweight processing algorithms for incident localization using audio and video signals.

4. To develop deep learning algorithms and models that operate at different tiers of the system in an integrated manner. Multi-view, multi-task and domain adaptation models (specifically, generative adversarial networks) will be learned from various sensors' observations at higher tiers of the systems. At lower tiers, the trained models will be used to perform classification tasks. The ultimate objective of the deep learning algorithms is to identify normal conditions and to detect anomalous situations.

5. To develop a testbed of sensing devices, consisting of cameras (with embedded microphones) and drones, which is planned, implemented, and deployed according to the strategies developed under earlier objectives. The testbed will be used to evaluate the algorithms and protocols developed under this project.

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