Internship Program 2024
Enabling XAI in IoT-enhanced Spaces
October 27, 2023

Project Description

With the emergence of the Internet of Things (IoT) and computing (cloud-edge) continuum technologies infrastructures are becoming more sensorized, fueling the development of smart space ecosystems and improving societal quality of life. As a result, smart spaces are becoming popular in many domains, including healthcare, education, building management, and more. This integration with the IoT brings much potential in revolutionizing the way that these environments operate. Initially, IoT sensors measure physical phenomena (temperature, energy consumption, luminosity) in a continuous way, producing streams of data. Such data is often used for analysis and predictions to either optimize different criteria (e.g., occupancy, user comfort, energy consumption, etc.), or identify and anticipate problems. To manage and control the data generated by IoT devices, AI algorithms can be used to enable smarter, more efficient, and more responsive devices to their environment.

To enable efficient decision making, it is increasingly common that predictions be accompanied by *explanations*, i.e., pieces of information either on the data, the models, or both for giving insights on why the predictions were made. For example, a smart building employs IoT devices to measure energy consumption of different plugs in households, as well as temperature of different rooms. Using this measurements as training data, a Machine Learning model can be used to predict the energy consumption of the air-conditioning appliance plug (label) using different IoT data features (e.g., temperature). Since this is a continuous setting scenario, at time t_1 we may have gathered D_1 data, which we use to train a decision tree M_1. At a later time t_2, incrementally we have obtained $D_1 \subset D_2$, along with a new trained model M_2. Let's assume the following predictions made by M_1 and M_2 for a test point p: $y_1 = M_1(p) =$ 10watts and $y_2 = M_2(p) =$ 50watts. An example of traditional local explanations for these two predictions could be $e_1 : p.temperature = 20$ while $e_2 : p.temperature = 35$. We argue that a more informative and correct explanation would be the information that the distribution of the training data has changed; it is not only that the current temperature is at 35 degrees, but also that the timestamps with high temperatures appear more often in the data than before t_1.

This internship aims to study the usage of data distribution changes through time for the construction of more pertinent XAI models for IoT-enhanced spaces. Use cases will be provided from existing data models and data instances from IoT devices deployed in smart spaces of the Institut Polytechnique de Paris (IP Paris).

The successful candidate will be considered for a 3 year PhD position at the end of the internship.

Internship Objectives

The selected candidate will be working on the following tasks:

- Get familiar with data models for smart spaces.
- Leverage datasets of smart spaces for prediction and decision making.
- Study data drifts and distribution changes in datasets for IoT space predictions.
- Propose explanation formalizations based on data distribution changes.

Qualifications

Master 2 or last year of engineering school.

Skills & qualities

- Fluent in English.
- In-depth knowledge of performing data statistics using Python.
- Good knowledge of ML analytics.
- Familiarity with Semantic Web (e.g., ontologies, knowledge graphs).

Useful information

- Starting date: April 2024 (flexible)
- Duration:: 5-6 months
- Location: Télécom SudParis, Evry/Palaiseau or Paris University, Cergy-Pontoise

Contact

To apply, contact:

- Georgios Bouloukakis, Télécom SudParis, `georgios.bouloukakis AT telecom-sudparis.eu`
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by providing the following documents:

1. CV
2. Motivation letter
3. Transcripts of the last 3 years
4. A course report or article written in English (if any)

References and Additional Reading

[1] İbrahim Kök, Feyza Yıldırım Okay, Özgecan Muyanlı, and Suat Özdemir. Explainable artificial intelligence (xai) for internet of things: a survey. *IEEE Internet of Things Journal*, 2023.

[2] Roberto Yus, Georgios Bouloukakis, Sharad Mehrotra, and Nalini Venkatasubramanian. Abstracting interactions with iot devices towards a semantic vision of smart spaces. In *Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation (Buildsys)*, pages 91–100, 2019.

[3] Andrew Chio, Daokun Jiang, Peeyush Gupta, Georgios Bouloukakis, Roberto Yus, Sharad Mehrotra, and Nalini Venkatasubramanian. SmartSPEC: Customizable Smart Space Datasets via Event-driven Simulations. In *The 20th International Conference on Pervasive Computing and Communications (PerCom)*, 2022.

[4] Nikolaos Papadakis, Georgios Bouloukakis, and Kostas Magoutis. Enabling Dynamic Smart Spaces using IoT-enhanced NGSI-LD Data Models. In *CWSI 2022 - 3rd IoT Connected World/Web Semantic Interoperability Workshop*, Delft, Netherlands, 2022.

[5] Johannes Haug, Alexander Braun, Stefan Zürn, and Gjergji Kasneci. Change detection for local explainability in evolving data streams. In *Proceedings of the 31st ACM International Conference on Information & Knowledge Management*, pages 706–716, 2022.