School of Computing, Engineering, and the Built Environment
Edinburgh Napier University

PHD STUDENT PROJECT

Application instructions:
Detailed instructions are available at :
https://www.napier.ac.uk/research-and-innovation/doctoral-college/how-to-apply

Prospective candidates are encouraged to contact the Director of Studies (see details below) to discuss the project and their suitability for it.

Project details

Supervisory Team:

- DIRECTOR OF STUDY: Dr Tomas Horvath (Email: t.horvath@napier.ac.uk)
- 2ND SUPERVISOR: tbc

Subject Group: Computer Science

Research Areas: Computer Science, Artificial Intelligence, Machine Learning, Data Science, Internet of Things

Project Title: Efficient Sensor Data Processing for Decision Support in AgriFood Applications (Beekeeping and Brewing/Distilling)

Project description:

Deploying sensors and utilizing artificial intelligence (AI) techniques, for monitoring and controlling the production processes as well as providing decision support for managers, became an everyday practice in modern agriculture and food industry (AgriFood) with numerous successful applications. Adoption of these techniques are, however, more successful on large-scale, while in case of small businesses is often limited by environmental, infrastructural, economical or technological factors. These factors determine some important attributes which should be considered when developing any so-called precision technology for (but not only) small-scale AgriFood sector.

First, the technology should be cheap, meaning minimal requirements for the used hardware, considering the conditions in AgriFood (e.g. humidity, dust, acidity). Also, if possible, the utilized data processing and AI techniques should be lightweight and computationally efficient, deployable on such hardware. Here,

utilizing the domain knowledge in the development of customized AI models can be useful in order to shrink the computation needs and the sizes of the developed models.

While utilizing cloud-computing in AgriFood solutions is usual, besides their still high price for small-scale businesses, these are not always applicable in rural areas with weak internet coverage. Here, another question emerges, i.e. how privacy-preserving a certain AgriFood solution is. Considering that the collected sensor data might reveal some "business secrets", so-called Federated Learning techniques might be considered.

Finally, an important issue in case of AgriFood solutions is the trust of the users in the system, its predictions and recommendations. For such, the use of explainable AI models are favorable. These might be useful also for getting better insight into the collected data, thus, connecting the resulting patterns to the domain knowledge.

The above mentioned attributes for an AgriFood solution (simple hardware, lightweight and customized AI techniques, utilization of federated learning) are in line with the main concepts of green computing, thus, leading to more sustainable solutions.

Since about 75% of world's AgriFood businesses are small-sized with substantial economical, societal, cultural and historical impacts, there is a potential in this PhD project with the following main objectives:

1) Implementing and testing durable (under AgriFood conditions), energy efficient and secure solutions for sensor data acquisition.
2) Developing lightweight, privacy-preserving and multi-modal machine learning (ML) methods with particular focus on interpretability and explainability.

The use-case application domains of the project, from where the data will be collected and the developed techniques deployed, are beekeeping (agriculture) and brewing/distilling (food industry), in which the supervisor of the project possesses good domain knowledge.

References:

[1] T. Mizik (2023). How can precision farming work on a small scale? A systematic literature review. Journal of Precision Agriculture.

[2] D.T. Várkonyi, J.L. Seixas Junior, T. Horváth (2023). Dynamic Noise Filtering for Multi-class Classification of Beehive Audio Data. Expert Systems with Applications, vol. 213, Part A.

[3] P. Kiss, T. Horváth (2021). Migrating models: A decentralized View on Federated Learning. Communications in Computer and Information Science, vol 1524.

[4] C. Gonzalez Viejo, S. Fuentes, A. Godbole, B. Widdicombe, R. R Unnithan (2020): Development of a low-cost e-nose to assess aroma profiles: An artificial intelligence application to assess beer quality. Sensors & Actuators B: Chemical, vol. 308.

Candidate characteristics

Education:

Minimum 2:1 degree in Computer Science

Subject knowledge:

Artificial intelligence, Data Science

Essential attributes:

- Deep theoretical background on Machine Learning
- Good programming skills (not just using libraries)

Desirable attributes:

- Experience with Internet of Things (IoT) and sensors
- Knowledge in web and mobile development