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

PHD STUDENT PROJECT

Funding and application details

Funding status: Self funded students only

Application instructions:
Detailed instructions are available at https://blogs.napier.ac.uk/scebe-research/available-phd-student-projects/

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: Andrew Livingstone (Email: A.Livingstone@napier.ac.uk)
- 2ND SUPERVISOR: Chan Hwang See

Subject Group: Built environment

Research Areas: Built Environment

Project Title: Low-cost digital twin for building performance monitoring and control system operation

Project description:

The UK government urges us to build 'better, faster and greener' to mitigate our housing shortage and move towards net-zero carbon homes. The rapid evolution of Digital Twin technologies in smart cities has enabled the early integration of these technologies in the credentials of building construction to achieve this target. In other words, the early construction credentials of a building would involve incorporating internet of things technologies that would help in creating a digital representation of a building. By implementing this, it proposes creating a digital copy or replica of physical assets, people, process, system or devices for varying management purposes of the physical assets. Creating a digital representation of

a building could provide valuable information into the management, use and life cycle of the building through the power of the evolving Internet of Things (IoT) Technologies.

By implication, the digital representation of the buildings can provide invaluable information for analyses and understanding of how the building is being used by the occupant. In addition, the digital representation of the building assets can further provide information on the health of the infrastructures installed in the buildings and can reduce maintenance costs. In other words, the data gleaned from the digital representation of the building could help to effect predictive maintenance instead of corrective maintenance. The data also can be related to all the interior and exterior parts of the building including the facilities that support the daily running of a building, then combining the technologies will provide useful data that could receive quality machine and deep learning treatments that would be used to unveil some latent information regarding the status of the building.

Meanwhile, it is still possible to create a digital twin of an existing building for the management and maintenance of the building. For example, surveying and understanding the architecture of an existing building, one could create a digital twin of the building to provide data from the infrastructures installed in the building. These would help to manage the building in terms of number of occupants, usage and ageing of the infrastructures installed to run the building and support the occupants. The idea of digital twin would reduce the amount of time, transportation costs and other resources that building owners, landlords and managers spend going to inspect a building, usage, infrastructure status, etc. Regardless of the data generated by an asset, space, lease, maintenance management systems or data from IoT, a digital twin can act as the hub to integrate information, provide context to it and generate insights that help to optimise building performance by eliminating silos.

This work will build upon four existing digital twin projects undertaken by Edinburgh Napier University and the New Model Institute for Technology & Engineering (NMITE). Additionally, Edinburgh Napier University's partnership with Trimble provides access to project support and access to Trimble technology systems. For example: Scan to BiM and building performance analysis software.

This PhD will investigate data flows in the Living Labs' design, manufacturing and construction and how the data can be extracted in a meaningful live dashboard format. This will require interdisciplinary skills, including sensor networks, computational and building performance research methodologies. This project will develop AI-based models to characterise the building and structural performance accurately and predict the behaviour of user's activity and shadowing. The research methodology includes sensor design, data acquisition, data interpretation, data analysis, software design and building information modelling, leading to new impactful models enabling the future smart building in the UK. The expected PhD main outcome will be a distilled version of data generated from several Living Labs in a clear and concise format that can be used to make evidence-based business decisions. This scientific approach can be applied with future work to remote inspections of construction operations to provide accurate build data for occupants and asset managers.

References:

[1] B. H. Mohammed, N. Safie, H. Sallehuddin and A. H. B. Hussain, "Building Information Modelling (BIM) and the Internet-of-Things (IoT): A Systematic Mapping Study," in IEEE Access, vol. 8, pp. 155171-155183, 2020, doi: 10.1109/ACCESS.2020.3016919.

[2] C. J. Turner, J. Oyekan, L. Stergioulas and D. Griffin, "Utilising Industry 4.0 on the Construction Site: Challenges and Opportunities," in IEEE Transactions on Industrial Informatics, vol. 17, no. 2, pp. 746-756, Feb. 2021, doi: 10.1109/TII.2020.3002197.
[3] A. Bucchiarone et al., "Smart Construction: Remote and Adaptable Management of Construction Sites through IoT," in IEEE Internet of Things Magazine, vol. 2, no. 3, pp. 38-45, September 2019, doi: 10.1109/IOTM.0001.1900044.
[4] A. Nugur, M. Pipattanasomporn, M. Kuzlu and S. Rahman, "Design and Development of an IoT Gateway for Smart Building Applications," in IEEE Internet of Things Journal, vol. 6, no. 5, pp. 9020-9029, Oct. 2019, doi: 10.1109/JIOT.2019.2926099.
[5] G. Bedi, G. K. Venayagamoorthy and R. Singh, "Development of an IoT-Driven Building Environment for Prediction of Electric Energy Consumption," in IEEE Internet of Things Journal, vol. 7, no. 6, pp. 4912-4921, June 2020, doi: 10.1109/JIOT.2020.2975847.
[6] W. Xu et al., "The Design, Implementation, and Deployment of a Smart Lighting System for Smart Buildings," in IEEE Internet of Things Journal, vol. 6, no. 4, pp. 7266-7281, Aug. 2019, doi: 10.1109/JIOT.2019.2915952.

Candidate characteristics

Education:

A first-class honours degree, or a distinction at master level, or equivalent achievements in construction or electrical & electronics or computer engineering

Subject knowledge:

A good fundamental knowledge of sensors of data gathering

Essential attributes:

- Data science
- Knowledge of IT, analytical skills and research methods
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:

- Building Information Modelling