MSc/BSc Project List

Charalampos Orfanidis
DTU Compute
chaorf@dtu.dk

October 8, 2024

Contents

1 Foot Smart Textile

Supervisor: Charalampos Orfanidis

Background: Digital knitting is a method that have enabled smart fabric that can be use in wide domain around activity monitoring and gesture recognition. Smart clothes made out of smart textiles have been introduced assist applications around human computer interaction (HCI), sports and health.

Project Description: In this project the student(s) will explore how smart textiles can be used for a specific scenario in smart health, namely monitoring biomarkers such as plantar pressure and gait pattern which are associated with neurological diseases. The key performance metrics to be investigated is the accuracy to capture the biomarkers, the energy consumption and the robustness of the system.

Recommended Background Knowledge: Electronics; C programming; AI; Networking

Key References:

- I. Wicaksono et al., "3DKnITS: Three-dimensional Digital Knitting of Intelligent Textile Sensor for Activity Recognition and Biomechanical Monitoring," 2022 44th Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), Glasgow, Scotland, United Kingdom, 2022, pp. 2403-2409, doi: 10.1109/EMBC48229.2022.9871651.
- Luo, Y., Li, Y., Sharma, P. et al. Learning human–environment interactions using conformal tactile textiles. Nat Electron 4, 193–201 (2021). https://doi.org/10.1038/s41928-021-00558-0
- Ali Kiaghadi, Seyedeh Zohreh Homayounfar, Jeremy Gummeson, Trisha Andrew, and Deepak Ganesan. 2019. Phyjama: Physiological Sensing via Fiber-enhanced Pyjamas. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 3, 3, Article 89 (September 2019), 29 pages. https://doi.org/10.1145/3351247

2 Battery-free Visible Light Communication

Supervisor: Charalampos Orfanidis

Background: Visible Light Communication (VLC) has received a lot of attention last decade as it can enhance RF based communications. One of the motivation of using VLC is that the ISM band is getting more crowded as more networks are deployed and RF communication becomes more challenging due to noisy environments. In that case VLC includes terahertz of license free bandwidth which can be used to design high capacity mobile data networks. Furthermore the inability to penetrate opaque objects provides an extra layer of security. Energy harvesting for VLC systems has been investigated but using wireless charging is a concept which has not been investigated and it be beneficial in several application scenarios.

Project Description: The main purpose of the project is to illustrate the benefits of combining VLC systems with wireless charging by carrying out a a systematic evaluation of a simple VLC system powered by an off-the-shelf wireless charger. Namely the project should provide practical results such as achievable bitrate/throughput on mobility/stationary scenarios using a VLC system based on an MCU. Designing a PCB which which will integrate all the parts of the VLC system and the wireless charging coil will be an optional target.

Recommended Background Knowledge: C programming; Basic PCB design principles; Basic electronics knowledge

Key References:

- X. Lu, P. Wang, D. Niyato, D. I. Kim and Z. Han, "Wireless Charging Technologies: Fundamentals, Standards, and Network Applications," in IEEE Communications Surveys & Tutorials, vol. 18, no. 2, pp. 1413-1452, Secondquarter 2016
- P. H. Pathak, X. Feng, P. Hu and P. Mohapatra, "Visible Light Communication, Networking, and Sensing: A Survey, Potential and Challenges," in IEEE Communications Surveys & Tutorials, vol. 17, no. 4, pp. 2047-2077, Fourthquarter 2015

3 Cross technology CSMA scheduling for LoRa - IEEE 802.15.4g

Supervisors: Charalampos Orfanidis

Background: LoRa is one of the most popular LPWAN technologies providing long range and robust communication. IEEE 802.15.4g Wi-SUN is another LPWAN technology operating in the same frequency band which is is prone to LoRa interference when they co-exist in the same environment. There are several collision mechanisms when it comes to low power wireless communication based on CSMA scheduling but that assumes that there is a communication among the networks that are willing to co-ordinate and share the medium with a schedule. That is not the case for LoRa and Wi-SUN since they use a different modulation scheme and they cannot communicate.

Project Description: The purpose of this project is to establish a cross technology communication protocol between LoRa and IEEE 802.15.4g Wi-SUN and transfer a schedule to avoid collisions between the two networks. The cross technology communication can be based on the energy emission of the Sub-GHz band.
Recommended Background Knowledge: Solid C programming skills; Basic computer networking principles

Key References:

- J. Shi, D. Mu and M. Sha, "LoRaBee: Cross-Technology Communication from LoRa to ZigBee via Payload Encoding," 2019 IEEE 27th International Conference on Network Protocols (ICNP), Chicago, IL, USA, 2019, pp. 1-11
- A. Gamage, J. C. Liando, C. Gu, R. Tan, and M. Li. 2020. LMAC: efficient carrier-sense multiple access for LoRa. In Proceedings of the 26th Annual International Conference on Mobile Computing and Networking (MobiCom '20). Association for Computing Machinery, New York, NY, USA, Article 43, 1–13.

4 Ocean IoT

Supervisor: Charalampos Orfanidis

Background: Underwater sensors are vital for a wide range of applications from monitoring the ecosystem to providing surveillance around critical infrastructure. The vastness of the oceans, limited options for wireless data transfer, and high cost of maritime installations act together to effectively prohibit deployment of sensors over a wide region of interest. Instead, sensors are either installed very sparsely or carried on sea-faring vessels providing only instantaneous data points and requiring repeat expeditions to identify trends and seasonal variations in the measurements. Terrestrial IoT approaches can be modified accordingly for the underwater environment and provide solutions towards the ocean IoT vision.

Project Description: In this project the student(s) will how explore acoustic waves can be used to establish underwater communication. Feasibility tests in lab environment will be carried to quantify the performance of the new solutions. Challenges posed by obstructed communication scenarios will be investigated as well.

Recommended Background Knowledge: Signal Processing; Electronics; C programming; Computer Networking

Key References:

- M. Jahanbakht, W. Xiang, L. Hanzo and M. Rahimi Azghadi, "Internet of Underwater Things and Big Marine Data Analytics—A Comprehensive Survey," in IEEE Communications Surveys & Tutorials, vol. 23, no. 2, pp. 904-956, Secondquarter 2021, doi: 10.1109/COMST.2021.3053118

5 Soil Powered Computing

Supervisor: Charalampos Orfanidis

Background: Human-caused climate damage and the rise of electronic waste have driven the computing community to seek alternatives to battery-powered devices that require frequent replacement and recharging. Soil Microbial Fuel Cells (SMFCs) show promise as a renewable, eco-friendly energy source, especially in harsh environments where traditional batteries and solar panels fail. However, SMFCs are still in early stages of development, with challenges like low power output and vulnerability to environmental factors hindering their real-world use.

Project Description: In this project the student(s) will explore different designs of SMFCs on a laboratory environment to explore their performance on harvesting energy over long time. The SFMCs will be 3D printed and assembled following a guide.

Recommended Background Knowledge: C programming; Embedded Systems; Electronics; 3D printing

Key References:

- Bill Yen, Laura Jaliff, Louis Gutierrez, Philothei Sahinidis, Sadie Bernstein, John Madden, Stephen Taylor, Colleen Josephson, Pat Pannuto, Weitao Shuai, George Wells, Nivedita Arora, and Josiah Hester. 2024. Soil-Powered Computing: The Engineer's Guide to Practical Soil Microbial Fuel Cell Design. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 7, 4, https://doi.org/10.1145/3631410

6 Zephyr OS for IoT

Supervisor: Charalampos Orfanidis

Background: Zephyr OS is a lightweight, real-time operating system tailored for resource-constrained IoT devices. Its modular design allows for optimized performance, supporting advanced networking applications like mesh networking and edge computing. With robust connectivity options and cross-platform compatibility, Zephyr enhances scalability and efficiency, making it ideal for building sophisticated IoT ecosystems.

Project Description: In this project the student(s) will how you can develop advanced networking applications in IoT such as using the Time Sensitive Network (TSN) based on the Zephyr operating system and will benchmark the network performance but also the resource allocation and the compare it with the state of the art.

Recommended Background Knowledge: C programming; Computer Networks principles; Operating Systems

Key References:

- M. Silva, D. Cerdeira, S. Pinto and T. Gomes, "Operating Systems for Internet of Things Low-End Devices: Analysis and Benchmarking," in IEEE Internet of Things Journal, vol. 6, no. 6, pp. 10375-10383, Dec. 2019, doi: 10.1109/JIOT.2019.2939008.
- `https://docs.zephyrproject.org/latest/index.html`

7 Intermittent Learning

Supervisor: Charalampos Orfanidis

Background: Intermittent learning is a field of computer science that performs machine learning by utilizing intermittently harvested energy. Energy harvesting, while eliminating the need for batteries to power an embedded system, is not necessarily providing a constant source of energy. The goal of intermittent learning, therefore, is to be able to create a system that can sense, learn, and infer, while also being able to halt its execution and resume where it left off in the case of a loss of power. The checkpoint to restore the system status after a cycle is stored to non-volatile memory.

Project Description: The purpose of this project will therefore be to set up a system that performs intermittent learning. A microcontroller will be used for systems with sensors, which will be connected to a power analyzer to evaluate the power consumption over a long term period. Improving the process by individually evaluating data points and improving the checkpoint process are the next steps to follow.
Recommended Background Knowledge: Solid Python programming skills; Embedded Systems; C programming; AI/Data Science

Key References:

- Seulki Lee, Bashima Islam, Yubo Luo, and Shahriar Nirjon. 2020. Intermittent Learning: On-Device Machine Learning on Intermittently Powered System. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 3, 4, Article 141 (December 2019), 30 pages
- Bashima Islam and Shahriar Nirjon. 2020. Zygarde: Time-Sensitive On-Device Deep Inference and Adaptation on Intermittently-Powered Systems. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 4, 3, Article 82 (September 2020), 29 pages. https://doi.org/10.1145/3411808