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IoT and the Environment

The Internet of Things (IoT) is having a tremendous impact on all sectors of industry, affecting global society. IoT deployments provide industrial settings with sensing and control capabilities at high resolution, hence enabling new levels of resource optimization and efficiency. IoT technology is also one of the core technologies enabling various smart scenarios, such as smart homes, smart cities, and smart regions, aiming to meet the needs of modern citizens more effectively and efficiently. IoT is already embedded within cars, trucks, locomotives, and aircraft to reduce maintenance costs and improve transportation safety. On a personal level, IoT-based devices provide customized health and fitness monitoring, letting users keep track of their physical activities and estimating caloric needs based on the latter.

In this fully digital society, one of the greatest challenges facing humanity is to preserve the environment for future generations. Citing an ancient Masai saying, Robert Baden-Powell (founder of the worldwide Scout Movement) said that "we did not inherit the world from our fathers, but we borrowed it from our children and we must return it better than we found it." Specific environmental challenges span the gamut from global concerns (such as combatting climate change) to local concerns (such as preventing groundwater contamination). It is a tough fight, but IoT technology can be used as the definitive weapon to eventually succeed.

In general, the opportunities for IoT to address even the toughest environmental challenges are endless. Smart buildings able to sense and model usage patterns can adapt the lighting, heating, and cooling to minimize energy consumption; sensing of supply and demand can be used to optimize the contributions of solar and wind power to the electrical grid; environmental sensors can provide early warnings of threats such as pests, diseases, frosts, and droughts, before becoming catastrophic events for crops. Imagine dense networks of sensing devices providing high-resolution, high-quality data, then used to reveal important trends, hence enabling corrective actions always guaranteeing the optimal result. Just as an example, figure out a wide ad-hoc network of autonomous IoT devices endowed with sensors able to sense the actual plants' needs in terms of water and nutrients. Thanks to specific IoT technology, the dream of providing the right amount of input, exactly when it is needed, is becoming reality. Besides the optimization of the watering schedules, temperature and humidity sensors can be used to predict late spring frosts, thus saving crops.

However, IoT can just as easily cause environmental problems. Reliable forecasts envision billions of low-cost IoT devices connected to the Internet. On a global scale, these billion devices produce petabytes of data, hence increasing energy demands for IT infrastructure dedicated to storing, processing, and analyzing such volume of data (besides the need to continuously cool such server machines). At the local level, each device has its battery, often not rechargeable, if not even replaceable. Therefore, both the device and its battery will need to be disposed of in an environmentally sustainable way. Said differently, no disruptive technology comes without major consequences.

This special issue features recent and emerging advances of IoT technology supporting the environment. Around 20 contributions were received and peer-reviewed, out of which five were selected for publication. These cover topics such as environmental monitoring in smart cities using drones, blockchains, and big data; futuristic autonomous transportation systems in health emergency settings; large-scale marine pollution monitoring systems and low-power long-range near field communication technology for monitoring harsh environments.

More in detail, Siyi Liao *et al.* contributed an article titled "Securing Collaborative Environment Monitoring in Smart Cities Using Blockchain enabled Software-Defined Internet of Drones". They propose a novel software-defined Internet of Drones (SD-IoD) architecture to enhance the support for heterogeneity and flexibility in large-scale environmental monitoring applications comprising drones. To enforce secure and efficient cooperation and interoperability of drone controllers, they provide a controller consortium blockchain that relies on a new cryptographic currency cooperation coin and a new consensus mechanism called Proof-of-Security-Guarantee (PoSG). Finally, they design a novel incentive mechanism to encourage controllers to maintain their security and provide safer services to other controllers.

Suparna De *et al.* co-authored the article "Inferring Latent Patterns in Air Quality from Urban Big Data", an interesting work providing a fine-grained analysis of air quality from diverse sensor data streams retrieved from regions in the city of London (UK). The analysis derives spatio-temporal patterns and reveals the interplay between urban phenomena such as human commuting behavior and the built environment, with the observed air quality patterns. The findings of this paper have important implications for the health of ordinary citizens and for city authorities who may formulate policies for a better environment.

In their article titled "Autonomous Transportation in Emergency Healthcare Services: Framework, Challenges and Future Work", Muhammad Khalid *et al.* introduce an autonomous transportation framework for emergency healthcare service combining autonomous vehicles and deep reinforcement learning. Briefly, the latter should identify emergencies and support the former to take correct and faster decisions when providing emergency health aid and transportation services to patients. Furthermore, this approach is envisioned to reduce energy consumption and environmental pollution in the smart cities of the future.

Hongzhi Guo *et al.* contributed an article titled "Internet of Things in Extreme Environments Using Low-power Long-range Near Field Communication" proposing the use of low-power IoT technology with onboard passive sensors and near field communication (NFC) capability to alleviate some extreme conditions of underground and underwater IoT deployments. Briefly, the existing magnetic induction-based NFC and other communication protocols are reviewed, together with their respective advantages and limitations. Finally, the overall system framework, the key technologies involved, and the main research challenges related to this interesting technology niche are discussed.

Finally, in "Toward Large-Scale Autonomous Marine Pollution Monitoring", Huber Flores *et al*. describe their research vision on large-scale autonomous marine pollution monitoring through coordinated groups of autonomous underwater vehicles (AUVs). According to this vision, groups of UAVs will be used to monitor the extent and the characteristics of marine pollutants. In this paper, the authors identify the key requirements and the enabling technologies to establish a research roadmap toward such a vision. Then, in the attempt to preliminarily assess the feasibility of the proposed system architecture, they carry out some controlled experiments addressing the classification of marine pollutants and collaborative underwater processing.

I hope you will enjoy reading this special issue!

Biography

Massimo Vecchio (mvecchio@fbk.eu) is an associate professor at the eCampus University and senior researcher within the OpenIoT Research Unit of the Fondazione Bruno Kessler (FBK). His current research interests include computational intelligence and soft computing techniques, the Internet of Things paradigm, and effective engineering design and solutions for constrained and embedded devices. Regarding his most recent editorial activity, he is an associate editor of the *Applied Soft Computing* journal and the managing editor of the IEEE IoT newsletters.