SelfSustainableCHI: Self-Powered Sustainable Interfaces and Interactions

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Abstract
The continued proliferation of computing devices comes with an ever-increasing energy requirement, both during production and use. As awareness of the global climate emergency increases, self-powered and sustainable (Self-Sustainable) interactive devices are likely to play a valuable role. In this workshop we bring together researchers and practitioners from design, computer science, materials science, engineering and manufacturing industries working on this new area of endeavour. The workshop will provide a platform for participants to review and discuss challenges and opportunities associated with self-powered and sustainable interfaces and interactions, develop a design space and identify opportunities for future research.

Author Keywords
Interfaces and Interactions; Internet-of-Things (IoT); Internet-of-Materials (IoM); Photovoltaics (PV); Electrochromic (EC) display; e-ink displays.

Background
Computational devices such as Internet-of-Things (IoT) connected sensors, actuators, smart and interactive displays, digital signboards, smartwatches, voice controllers, etc. have all made tremendous progress over the last 10 years. However these systems must typically either be

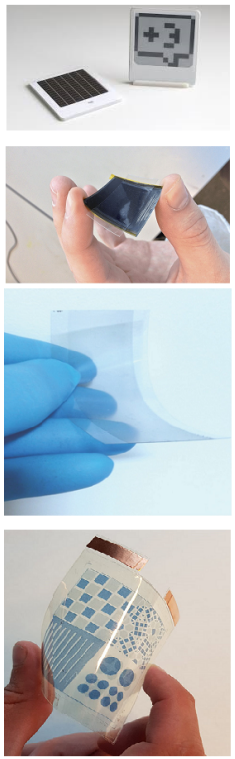

Figure 1: Top:Ultra-low power displays combine an e-paper display with photovoltaic energy harvesting [8], Middle two: flexible and transparent PV materials [7], [15], Bottom: transparent and flexible displays based on electrochromics [10].

plugged into a constant source of energy or rely on batteries.

The growing significance of climate change suggests that we cannot rely on these same sources of energy forever. With demand for devices such as those listed above growing globally as standards of living increase, the devices and services we use, plus the energy sources that power them must be more sustainable. A two-pronged strategy naturally emerges – powering our technologies from renewable sources while also making more intelligent devices that are more energy efficient.

Energy harvesting is a promising solution. Many researchers and industries are investigating novel solutions to harvest and store energy to achieve self-sustainable IoT devices. Research into ambient energy harvesting and ultralow power electronics has produced some interesting devices which are capable of harvesting energy from a variety of sources, including ambient indoor lighting [2], thermal sources [14], mechanical vibrations [6], and ambient RF [12].

The amount of energy harvested clearly governs what's possible–sensing, actuation, communication or storage are all possible and have been demonstrated in various self-sustainable applications. For instance, photovoltaic (PV) materials have been combined with ultra-low power displays (see Fig 1 (top)) [8].

To allow self-sustainable devices to have more functionality, energy harvesters can be used not just as power sources but also as self-sustainable sensors. For example, photovoltaic sensors that harvest energy from light can be used to detect changes in ambient light intensity, and also to detect the motion of hand gestures. Watches and eye-glasses have been prototyped using light to both detect hand gestures with a high degree of accuracy and provide self-sustainable operation [13]. Another example is to use mechanical energy harvesters to both sense mechanical vibration and communicate that information. SATURN [4, 3] is a thin flexible material which can sense tiny mechanical vibration caused by human voice or touch and then transmit it using RF backscatter technology (see Fig 2). Ubiquitous presence of such self-sustainable, or very low energy, requiring surfaces can provide enormous contextual understanding, interactive and surveillance capabilities.

Since power is a major design constraint for the functionality a self-sustainable device can provide, researchers have worked on leveraging in-situ power sources to design applications. For example explicit interaction performed on a device by a user can be used to power it. Interactive Generator (InGen) [5] and Peppermill [16] are examples of human-powered user interface devices which scavenge energy from the physical effort required to operate them. For example, InGen supports both haptic feedback and wireless communication based entirely on energy provided by the user during interaction. Another example of an in-situ power source is the wireless infrastructure present in the environment, be it phone or RF transmitters. RFTouchPads [9] and Tip-Tap [11] leveraged radio-frequency identification (RFID) technology nearby to allow for 2D touch sensing and discrete 2D fingertip input respectively. RF fields have been shown to allow interaction with devices with 3D gestures [1]. Mobile phones carried by users can also be leveraged as wireless power source (NFC [18]) or communication (e.g FM backscatter [17]) method.

Another trend in self-sustainable devices is to build them in a form factor that they can be easily instrumented onto everyday objects and surfaces to support more natural user

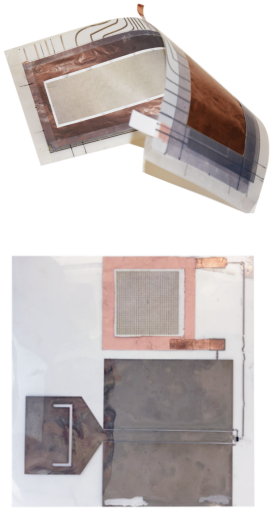

Figure 2: Top: SATURN - thin and flexible self-powered microphone [4] , Bottom: ZEUSSS : Zero-energy Ubiquitous Sound Sensing Surface [3].

interaction. Self-sustainable displays that are flexible, transparent and coloured have been made using patterned PV materials [7], [15] (see the example of flexible and transparent conducting adhesive of PV materials in Fig 1 (middle)). Customisable electrochromic (EC) displays [10] (see example of display in Fig 1 (bottom)) enable unique devices that show promise of being practically incorporated into any domestic object. SATURN [4, 3] is a wireless mechanical sensing material which looks and feels so like paper that it can be embedded into everyday objects, yet it behaves like a wireless microphone (see Fig 2). Finally, advances in additive manufacturing, flexible electronics and energy harvesting techniques allow us to build novel self-sustainable computational materials which in the words of Mark Weiser, "can weave themselves into the fabric of our everyday lives until they are indistinguishable from it", leading to the rise of a new generation of computing, Internet of Materials (IoM).

Workshop Topics of Interest: The topics of interest for the workshop include, but are not limited to the following:

- Methods, materials, and technologies for self-powered interfaces and interactions.
- Novel interfaces and interaction styles afforded by energy harvesting and low-power materials.
- Scenarios and contexts of use for sustainable interfaces and interactions.

Goal of the workshop: In this workshop, we will discuss the challenges and opportunities associated with self-powered and sustainable interfaces and interactions. It will bring together an international and cross-disciplinary group of researchers from academia and industry to collaborate and explore the the topic.

Organisers

The organising team combines expertise and interests from material science, HCI, ubiquitous computing and system engineering.

Yogesh Kumar Meena is a Research Officer in the Future Interaction Technology Lab at Swansea University. His research focuses on Self-Powered Internet-of-Things (IoT) devices (photovoltaic cells, digital displays) and Human-Machine Interface (multimodal interactions, brain-computer interfaces, gesture detection).

Nivedita Arora is PhD student in Ubiquitous Computing Lab at Georgia Institute of Technology. She combines learning from HCI, material science, chemical, electrical and mechanical engineering to develop self-sustainable computational material.

Xing-Dong Yang is an Assistant Professor of Computer Science at Dartmouth College. His research contributes new concepts and working prototypes that advance the technology of interactive smart "things" through (1) better input devices and techniques; (2) more expressive non-visual output mechanisms; and (3) interactive systems that consume less power.

Markus Löchtefeld is an Associate Professor in the Department of Architecture, Design and Media Technology at Aalborg University, Denmark. His research focuses on wearable and tangible computing as well as novel prototyping and fabrication techniques.

Matt Carnie is Associate Professor in Materials Engineering, at the College of Engineering, Swansea University. He works on a number of photovoltaic technologies, not least perovskites which have shown exceptional ambient light harvesting.

Niels Henze is professor for Media Informatics at the University of Regensburg. His research interests are mobile human-computer interaction and pervasive computing. His recent work focuses on what makes mobile devices social acceptability and how we will interact with them in the future.

Steve Hodges joined Microsoft's Cambridge research lab in 2004 with the ambition of building hardware systems that change people's perceptions of technology and how it can be used. His technical expertise spans interactive systems, connected devices, wireless communications, novel sensing and displays, embedded camera systems, location systems, energy management, security, wearable technologies and rapid prototyping.

Matt Jones is a research professor at the Computational Foundry, Swansea University. His work considers both emerging technologies and "emergent" users in rural and urban settings notably in India and sub-Saharan Africa.

Gregory Abowd is Regents' Professor and J.Z. Liang Chair in School of Interactive Computing at Georgia Institute of Technology. His research interests concern how the advanced information technologies of ubiquitous computing (or ubicomp) impact our everyday lives when they are seamlessly integrated into our living spaces.

Website

The workshop web pages can be found at (http://cs.swansea.ac.uk/~SelfSustainableCHI/).

Pre-Workshop Plans

We will distribute a call for position papers in design, computer science, materials science, engineering and manufacturing communities. We will announce the Call for Participation in mailing lists and calendars (e.g., ACM, CHI-announcements, Interaction-Design.org, WikiCFP) and social media (e.g., Twitter, Facebook). The calls will also be posted on the workshop website, along with other details about the workshop. Furthermore, we will directly contact researchers and practitioners who are likely to be interested in the workshop and write to relevant institutions, projects and companies. We will continue our efforts of promoting the workshop and getting in touch with potential participants during the period leading up to the position paper deadline. We have already made a list of 40 potential collaborators and attendees from industry, startups, design/HCI, material science, computer science and engineering.

Workshop Structure

The one-day workshop will be organized in three phases. The workshop will start with an introductory round and an overview of the grand challenges and opportunities in self-powered sustainable interfaces and interactions research. Then three phases will be used to drive an agenda for future research and innovation. These phases will be seeded by the participants' position papers and prototypes.

Phase 1: Technological possibilities

- This phase will concentrate on deepening understanding of the materials, methods, technologies available for self-powered interfaces and interactions.

Phase 2: Interface and Interaction Paradigm Shift

- Given the emerging materials, methods, and technologies, this phase will explore the features of the new interaction paradigms that they afford. We will, for example, consider granularity of input/ output and interface dynamics (e.g. speed of response). We will also consider possible applications afforded by this

paradigm shift, and highlight potential timescales for adoption.

Phase 3: Setting an agenda for transformation

- The outcome of this phase will be a coherent set of research directions that will enable other researchers to pursue the goal of creating technological futures that will enable rich digital interactions through responsible and sustainability-orientated innovation.

Post-Workshop Plans

The results of the workshop will be communicated to the larger HCI community via a magazine article (e.g., ACM Interactions). In this article, we will define future design spaces and opportunities for future research.

We will also invite all workshop participants to submit an extended article of their submission for a special journal issue on Self-Powered Sustainable Interfaces and Interactions (e.g., in Personal Ubiquitous Computing). This information and call for papers will also be shared on the website and will be open to other interested researchers in the community.

Call for Participation

We invite position papers for the CHI 2020 Workshop on Self-powered Sustainable Interfaces and Interactions. This one-day workshop will offer a cross-disciplinary forum of discussion and knowledge exchange for both academics and practitioners.

This workshop focuses on three grand challenges in self-powered sustainable interfaces and interactions research:

- Methods, materials, and technologies for self-powered interfaces and interactions.
- Novel interfaces and interaction styles afforded by energy harvesting and low-power materials.
- Effective and delightful scenarios and contexts of use for sustainable interfaces and interactions.

Researchers from both academia and industry with an interest in research into self-powered sustainable interfaces and interactions are invited to submit a position paper. This position paper should address one or more of the workshop's three grand challenges or suggest another (we encourage diversity and provocation). All submissions will be reviewed by the workshop organizers. Accompanying demos are encouraged, and will be allocated time in the workshop agenda.

Participants will be selected on the basis of the quality of their position paper and on the basis of background and perspective; we are seeking to bring together a cross-disciplinary mix of perspectives. At least one author of each accepted paper must register for the workshop and for one day of the conference itself. Participants will be invited to present a position statement at the workshop and will actively engage in a discourse on the meaningful design space for sustainability of self-powered interfaces and interactions in HCI.

For further details or to submit a position paper, please see the workshop website: http://cs.swansea.ac.uk/~SelfSustainableCHI/

Acknowledgments

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