Selfsustainable Assistive & Accessible Technology for Low Resource Settings

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Abstract
There will be over 2 billion people globally who require assistive technology by 2020 however currently only 10% of people who need such technologies have access. New ways of creating interfaces which allow for sustainability for the user and the planet are essential if we are to ensure no one is left behind. This paper explores the issues of design and development of technology in low income settings. It lays out thinking in three areas: 1) Powering the next generation of AT ;2) Materials for novel disability interactions and 3) Accessible, adaptable repairable AT.

CHI 2020 Extended Abstracts, April 25–30, 2020, Honolulu, HI, USA.

ACM ISBN 978-1-4503-6819-3/20/04.
DOI: https://doi.org/10.1145/3334480.XXXXXXX
*update the above block & DOI per your rightsreview confirmation (provided after acceptance)

Author Keywords
Authors' choice; of terms; separated; by semicolons; include commas, within terms only; required.

CSS Concepts
• **Human-centered computing~Human computer interaction (HCI)**; *Haptic devices*; User studies; Please use the 2012 Classifiers and see this link to embed them in the text: https://dl.acm.org/ccs/ccs_flat.cfm

Introduction
The world's population is ageing, and more people are living a higher proportion of their lives as people with a disability. The majority of people living with a disability are poor and live in low resource settings. In fact, there is a known link between poverty and disability with each fueling the other. A quarter of the world's urban population live in informal settlements [7], where the digital and physical infrastructures as sewerage and electricity and are not guaranteed. These challenging circumstances impact on people's quality of life [13].

Figure 1: Typical street in Kibera

Figure 2: Mobile phone stall in Kibera Kenya (an informal settlement in Kenya).

Assistive technologies (AT) such as wheelchairs, hearing aids, prosthetic limbs help a person overcome a physical sensory or cognitive impairment [14]. The WHO estimates 2 billion people will need AT by 2050. However, currently only 10% have access to devices. HCI has a central role to play in the future design of AT and accessible digital technologies. The Disability Interaction Manifesto [5] lays out a path to exploring how we can learn from and leverage the knowledge gained from designing with disabled people to develop new design paradigms and along the way new materials, devices and experiences.

Within low resource settings, such as informal settlements, there are increased barriers – a lack of resources. However, what is often ignored is the surplus of other resources. People are resourceful, keeping a practice of repair and recycling going by necessity. This leads to a highly resourceful workforce of assistive technology providers in low and middle income countries [6]. People are also resourceful and adaptable to new opportunities. This can be seen by the rapid adoption of mobile technology by people in the Global South and the number of business opportunities helped by mobile money.

Therefore digital, especially the next generation digital, has huge opportunity to overcome the barriers which disabled people face globally especially people living with disability in conditions of informality. We identify three areas of opportunity for selfsutainableHCI within the space of assistive technology and accessibility, we do this by presenting thinking in three areas: 1) Powering the next generation of AT; 2) Materials for novel disability interactions and 3) Accessible, adaptable repairable AT. We hope these areas will provide context for further exploration within the workshop. which we hope can be further explored

Powering the next generation of AT

Globally we need to reduce our power consumption and adopt new ways of generating power which reduce the human impact on the delicate ecosystem of Planet Earth. Within the domain of AT power consumption can be produced first by increasing the accessibility of mainstream products and services thereby negating the need for the creation of specialist devices. When needed AT should be designed to create desirable user experiences. Currently powered devices such as prosthetics, scoters and wheelchairs are frequently made to be difficult to use due to the weight of the power used and a lack of intuitive interface leaving many users making shorter journeys than they would like and the power would allow for due to a lack of confidence and fear of being stranded [9]. The second issue is that assistive technologies often make use of off the shelf batteries which are significantly over specified for the task; in fact the power requirements for a scooter were only very recently derived [10].

Power is also an issue when it comes to monitoring use of devices. The liner of a prosthetic device which is the main interface between the skin and the prosthetic is a ripe area for smart technology. Skin problems are the main reason for lack of use of a prosthesis as an amputated limb cannot dissipate heat effectively. New devices such as the ‘ubi-sleeve’ are under development which would monitor temperature, humidity and prosthesis slippage behavior during everyday prosthesis wear [12]. However, powering such devices, or devices such as active cooling systems to help control temperature would radically improve the quality of life of prosthesis users. Similar self-powering materials could also be extended to the space of exoskeletons, which is ripe for user-centred design practices [3].

Materials for novel disability interactions

Up until now the advancement of technology has generally centred around rigid materials, and the ease with which these materials can be processed and manufactured. As our technology now more and more takes up the space at the direct interface with our bodies, we require a push forward to increase the capability of our soft material technology. Additive manufacture is getting close to a state of maturity for producing product level direct print in rigid materials that can withstand extreme conditions, however the production of highly soft complex architectures is lagging behind. As these new ranges of material properties become readily available to designers, the scope for soft active, meta-materials that are highly suitable for direct skin contact will bring about new possibilities in the way assistive technology can interface with the body.

Additionally, the printing of active composite chainmail fabrics with a range of potential complex surface-based actuation properties is becoming possible. Responsive fabrics as a concept is not new but lack of appropriate actuators, and the considerable challenges of manufacturing such an actively interdigitated mechanical system has slowed progress [15]. Ransley *et al.* recently introduced a novel type of smart textile with electronically responsive flexibility. This opens up the missing requirement of individual actuation at each linkage point of the chainmail via the use of shape memory alloys [15].

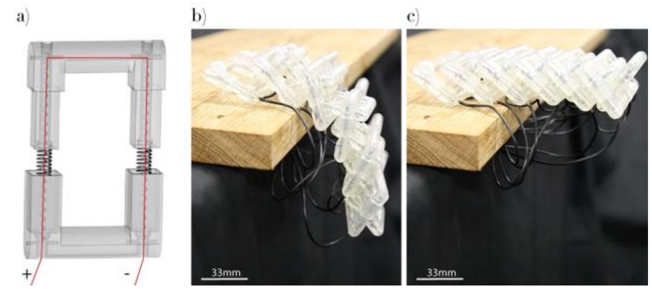

Figure 3: (a) Design of a shape-controlled chainmail linkage where the linear couplings on each side both contain a pair of nested springs, the equilibrium point of which can be adjusted through heating the internal NiTi coils via Joule heating, with charge flowing along the path shown in red. A 6 × 2 physical prototype was fabricated using an SLA 3D printer, and shown to be electronically reconfigurable between flexible (b) and rigid (c) states. Reproduced with permission.

Accessible, adaptable repairable AT

The culture in high income countries for AT provision is one which is very linear and not circular. People simply throw away or abandon AT which no longer serves their needs. Abandonment rates are generally accepted to be around 33% [11]. One issue driving abandonment is that repair and services are far away from where people live [1]. However, this is now more possible to counter given the rise in makerspaces and a growing movement of makers globally, which is being leveraged by disabled people to make their own AT [8]. The differences in approach by traditional prosthetists and makers are well captured by Hofman *et al.* [4]. Clinicians looking to prevent harm to the individual whilst the maker looking to create a movement to provide AT to all. However, between these two positions is a space where new technology and processes can be developed that could give confidence that no harm would eb done whilst providing greater access to the millions of people globally living without AT.

At is often designed with an attitude of one-size-fits-all; whereas new design paradigms allow for a remixing of technologies to allow for a one-size-fits-one design paradigm [5]. What if the shape of a phone could adapt to a person's ability to hold it. This would be better for people with mobility impairments but also good for everyone as we juggle the holding of multiple devices.

Within high income settings there is often a focus on design for the individua- as we just stated this would allow for increased usability for the individual. However, within low resource settings a new concept could be introduced – that of design for community use. What if power could be shared and communities or devices could be connected to power other devices. This idea emerges from the ways in which technologies are used in low resource settings. For example, in an upcoming paper [2] the ways in which visually impaired people use mobile phone technology in informal settlements in Kenya demonstrates that direct interactions between eh VIP and the phone is only one of a range of interaction types many of which were 'supported interactions'. These supported interactions were enabled by community members known to the VIP.

Conclusion

We believe that the next generation of AT could be powered by new materials and interfaces, created using new methods of manufacture and design, which will ultimately allow people to personalize their AT and repair it locally when it breaks.

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