Forays into Disability Discrimination Legislation and Wearable Computing

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Abstract
A significant amount wearable computing research is directed towards the development of systems which may help people with disabilities. These systems are increasingly likely to be developed by end users, and at the same time be inherently disruptive. Whether or not a system which is developed under such a regime counts as a reasonable adjustment is an unexplored question, yet very significant if disabled people are to fully benefit from wearable assistive technologies. At the same time, there is also the theme of whether a wearable computing system could also be used to enforce accessibility, by offering a convenient measure of whether this concern is being appropriately met. This project is therefore aimed at bringing together the domains of wearable computing and disability discrimination law, to the mutual benefit of both fields.

Author Keywords
Disability Law; Wearable Computing.

Introduction
Wearable computing is perhaps inherently disruptive as a field. The first wearable computing system, developed in order to track the path of a ball for the purposes of gambling on a roulette wheel, was outlawed as an emergency measure by the State of Nevada in 1985 [14]. Since then, proposed and implemented new
systems in this space have challenged social norms, and have often attracted contention in relation to privacy. For example, active badges were used in order to train patients in a home for people with dementia, but as discussed in Beckwith [2] this raised strong challenges in respect of consent. More recently this has been brought to the public attention by Google Glass, whose predecessors – developed over the last decades – essentially contain (or could contain) detailed logs of individual user activities. Recent media coverage has documented a wide range of concerns, including efforts to ban this system (and others like it) in Cinema’s, Casinos, and even whilst driving [6].

Yet, at the same time, these systems also have great potential in assisting a wide range of people with disabilities, by prosthetically helping to correct for or ameliorate a range of disability related symptoms. For instance, this could be as simple as a wearable sensing system for people with Parkinsons [1], or as complex as a system which provides social directions to people who have autism [13]. Going forwards, these solutions could easily be developed in a DIY fashion [7], effectively serving as ‘app’s’ developed by an end user for a given wearable computing application.

The issue is that these platforms are contentious, and any system might to some extent infringe on the rights of others, making it challenging to show that a disabled person is entitled by law to use it as a reasonable adjustment. If it is not possible to do this, then the effect is that person with a disability cannot show that they are entitled to use a system, hindering their inclusion in wider society. Whilst there have been a range of investigations concerning the permissibility of some of these technologies, perhaps notably Nguyen et. al’s investigation of the Sensecam [12], and investigations in respect of the personal audio loop [5], it is unclear how these will extend to systems deployed in practice, and how social attitude’s - and effectively therefore how legal reasonableness might evolve going forwards. Current methods for testing and evidencing the (legal) reasonableness of a system simply do not operate on a suitable timescale as to be useful for wearable computing, making this a concern which requires substantial investigation going forwards.

At the same time, it is well known that accessibility standards, including in the built environment, are often not implemented in practice. This is despite them being enshrined in legislation, due to the complaint based nature of the law being ineffectual from an enforcement perspective. The effect of this is to help exclude people with disabilities from being able to access wider society, and fully enjoy public space. Yet, activity recognition could be used as a tool to bridge this gap in respect of evidence. Most likely this would initially serve as a ‘soft-law’ approach, where the relative accessibility of a space (or not) is mapped out clearly and automatically in a transparent fashion, encouraging organizations to take additional steps to make buildings accessible.

Activity recognition could also be used to sense the reasonableness of an adjustment, for instance by tracking the degree of user engagement with activities of daily living, or other physical activity measures. However, a clear challenge here would be to determine how to make activity recognition convincing in relation to a court of law, and demonstrate to a suitable standard that a given intervention is a sufficient improvement for an adjustment to be reasonable.
This leads to three concerns (or forays) for this PhD Project, which are expanded upon below:

- Sensing the accessibility of a public space.
- Using activity recognition in an evidential context.
- Negotiating reasonableness of a wearable system.

### Sensing Accessibility

There does not currently exist an automatic means for measuring accessibility in a public space, although there have been previous efforts which have used a wheelchair as a platform for measuring the ‘roughness’ of a surface. Instead, accessibility is measured directly using an access audit, where an expert documents in detail a given space. This suffers from the limitation of being costly, and flowing from this, means that these assessments are either not done at all, or are often out of date, limiting their usefulness. There have been efforts to employ crowdsourcing, but then this lacks detail and objectivity, given the wide range of different groups of disabled people and the consequent range of obstacles faced when utilizing a given public space, meaning that what would be perceived as accessible to one person would be different compared to another.

### Progress to Date

A wheelchair based sensing platform has been developed which can identify accessibility related features with a reasonable degree of accuracy. The idea is that manual wheelchair users, when interacting with elements of the built environment, create discrete activities which can be automatically recognized. We can identify between lifts and hard lips using a segmentation based paradigm, and movement based...

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**Figure 1. Examples of Accessibility Related Activities**
activities (such as interactions with ramps, manual doors, and obstructions) using an activity recognition framework developed specifically for this purpose. Examples are illustrated in Figure 1. Future efforts will involve co-design of a final system with a broad range of manual wheelchair users, and development of an improved measurement system which translates sensed events into a direct measure of accessibility.

**Activity Recognition as Evidence**

Wearable computing platforms almost always contain a suite of sensors, which could be used as a basis for activity recognition. So far, these systems – unlike for instance GPS or mobile phone localization – have not been used in a court of law to prove the efficacy of a system, or even in a criminal court. In some respects this is unsurprising; most judges, and indeed lawyers, are mathematically illiterate (like the vast majority of the population at large), with there being a range of tales indicating how judges debated statistical significance [11], and the unfortunate case of R vs T [3] in relation to forensic evidence in a criminal trial. Yet, under the civil system of evidence, an activity recognition system would likely fit the appropriate burden of proof (statistical significance); the challenge is how to develop a system so that it is persuasive, evidentially, under the rigors of a legal context.

Effectively this is a science communication challenge. But at the same time, it also calls for the need of a more detailed consideration of how we evaluate an activity recognition system ourselves, stepping beyond the work of Ward et al [15], and developing a set of criteria which map appropriately to legal situations, including a determination of what forms of datasets are appropriate. Whilst this PhD will focus upon a modest scenario for this purpose – activities of daily living – one could also imagine this being extended into cases where events pertaining to an individual disability. Problem behavior for developmental disabilities could be one such example (as discussed in [9]), which would be even more challenging from a legal perspective because these activities are not even clinically well understood, nor do they occur outside of people who have these disabilities, making it problematic both to collect appropriate datasets, as well as developing suitable metrics and models.

**Progress to Date**

So far, interactive prototypes have been developed aimed at communicating how an activity recognition system operates, in order to gain an intuition. These were expanded from the Break-time Barometer project [10], where an interactive system were developed which involved the direct communication of signal data. The next step is to engage directly with lawyers in order to fully explore how activity recognition could be used as a convincing means of evidence in a civil case, and therefore to support a demonstration of reasonableness. I have also engaged directly in Activity Recognition research, for instance I collaborated on developing new feature extraction methodologies [4], as well as research on annotation correction [8].

**Negotiating Reasonableness**

One, unexplored concern, is when systems such as Google Glass are used in order to ameliorate a disability, are there circumstances where these systems would count as a reasonable adjustment. At present, this is almost entirely uncharted in the legal sphere, with assistive technologies – be they as simple as ramps – taking an inordinate amount of time (i.e. the
generation of legal precedent) for it to become clear as to the extent to which someone is entitled to have, access, and use them.

Given the length of time in which an app could be developed – possibly over a weekend – the law is clearly unsuitable for this technology, if each application developed for them has to be considered on a case by case basis, as the development will move far more rapidly than the law. This raises the question of whether families of assistive technologies – e.g. the Google Glass – could be generally regarded as an assistive technology, irrespective of how they are used in actuality (or whether a user could demonstrate a disability). If this were to be true – this point being currently undetermined in law – then it would also have strong implications of the permissibility of wearable computing generally, and remove an entitlement for an organization or public space to prohibit or curtail its use on their premises.

This also raises very interesting implications for the support of wearable technologies. Many systems would benefit from the instrumentation of the built environment, be it access to Wifi connections, or indoor location systems. These would be required in order to fully support a wide range of disabilities, and as such, could easily become reasonable accommodations in the same way that other building features are already considered as being so. Yet, at the same time, guaranteed provision of these services in public spaces would also support a wide range of wearable technologies. Consequently, in addition to permissibility, disability discrimination legislation could lead to a range of new avenues for wearable technology, which would extend well beyond those with disabilities, and benefit all users of wearable systems.

**Progress to Date**

With colleagues, I am engaged in progressing the development and evaluation of a suitably disruptive wearable computing system which would also clearly sit as a reasonable adjustment under Disability Discrimination Law. At the same time, an in depth review of Disability Discrimination Law has already been completed, with a discussion paper [9] published in order to begin charting how this domain impacts upon wearable and ubiquitous computing at large.

I have also been directing a research project which explores the challenges of postgraduate researchers with disabilities, which has been of great assistance in charting the challenges in accessing and using assistive technologies in environments where they are likely to be refused permission to be used, and the fact that it is very challenging to determine what might best help someone (making rationalizing whether an adjustment is appropriate inherently problematic).

**Conclusion**

The three investigations set out about are challenging in a diverse range of ways and forms, and all enter unchartered territory. They also lack strong precedent, whilst also having a strong bearing of a wide range of wearable technologies going forwards, especially in respect of permissibility. Yet, whilst challenging, pursuing these going forwards could present significant rewards, both for the inclusion of people with disabilities, and for enabling wearable technologies to be more fully a part of our everyday society.
Biography
Reuben Kirkham is a second year PhD student at Culture Lab, Newcastle University. His research interests span activity recognition, disability discrimination law, and social inclusion. Currently he is supported by an EPSRC student scholarship as well as an additional scholarship from Google. He also holds a research grant designed to investigate the experiences of postgraduate researchers with disabilities.

References