

# From Audiopaper to Next Generation Paper

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## ABSTRACT

It has been 24 years since the publication of Wellner's (1993) digital desk, demonstrating the augmentation of paper documents with projected information. Since then there have been many related developments in computing; including the world wide web, e-book readers, maturation of the augmented reality paradigm, embedded and printed electronics, and the internet of things. In this talk I draw on some of my own design explorations of augmenting paper with sound over the years, to illustrate the value of 'audiopaper' but also the way these explorations were rooted in the applications and technology of the day. I show that two key technologies have been important to the implementation of audiopaper over the years, and that the bigger opportunity is in connecting paper to the web. This culminates in a vision for two future generations of paper which communicate and interact with the digital devices around them

## CCS Concepts/ACM Classifiers

• **Human-centered computing** → **Human computer interaction (HCI)**

## Author Keywords

Augmented paper; newspapers; next generation

## INTRODUCTION

Debates about the future of reading have changed in recent years with the commercial success of e-books and tablet-based reading devices like the Kindle and iPad. These developments fulfill earlier predictions about the feasibility and attraction of screen-based alternatives to paper, and are now leading to falling print sales for books, magazines and newspapers. However, as in previous periods of this debate, paper lives on. It continues to be read in conjunction with screen-based material of an increasingly multimedia form. Furthermore, efforts to link paper itself to the web are gathering pace, with the growth of tagging technologies, augmented reality apps and advances in printed electronics [e.g. 4, 5].

In this talk I argue that instead of seeing paper and screen as opposing technologies for reading and writing, we should see them as complementary and able to interact with each other. In particular, multimedia information could be presented on nearby devices with screens and/or speakers when reading paper

documents of a variety of kinds. This leads to various paper-and-screen or paper-and-sound experiences that combine physical and digital information in new ways. I illustrate this in relation to my own previous work on augmenting paper photographs and newspapers with audio, and go on to describe the vision of a new project in which we are starting to define two future generations of augmented paper connected to the web.

## AUDIOPRINTS

*Audioprints* can be defined as printed photographs with associated sounds. Myself and colleagues at HP Labs first began developing audioprints in the context of a series of studies on 'audiophotographs', which we argued were a new media form lying somewhere between silent photographs and video [1, 2]. Ambient sounds could be captured around the time of taking a photograph, while voiceover or music can be added later to enhance memory and improve storytelling around images. While audiophotos could be played back on screen-based devices just like video clips, they also lent themselves to playback from printed photographs in a way that video did not. Our earliest experiments to playback sound from paper involved encoding sound files as a printed pattern on the back of a 6" x 4" photograph, and scanning this pattern with what we called an *Audioscanner*. An alternative implementation used an embedded chip in the paper, which stored up to 30 seconds of high quality audio for playback in a handheld *Audioprint player*. This was a kind of MP3 player of the day (see Figure 1), and could now be replaced with a smartphone. A final implementation used the printed photograph as an index to sound files stored elsewhere. This took the form of an *Audiophoto desk*, with an overhead camera and hidden computer able to recognize individual photographs from a table surface and fetch their associated sounds to play at the desk. Each of these technologies had advantages and disadvantages with regard to their use in audiophotography, but all received positive feedback in small scale user studies. In every study comparing paper and screen-based playback of audiophotos, consumers felt there was a role for both.



Figure 1. The Audioprint player

## INTERACTIVE NEWSPRINT

*Interactive newsprint* was the name of a project and technology for augmenting printed newspapers with associated sound. It

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emerged from a prior project called Bespoke in which we had worked with local community reporters to publish a local printed newspaper and website every month. The printed paper was preferred to the website, despite the website having recorded interviews, music and videos that could have complemented the printed word [6]. This led us to create a hybrid system in which the printed newspaper became an interface to web-based audio 'annotations'. We used printed and embedded electronics to instrument the newspaper pages with capacitive touch sensitive buttons and wireless communication. Pressing these areas caused associated audio clips to play through wireless speakers worn by the reader and paired with an internet device (see Figure 2). The experience was like reading a newspaper and listening to related podcasts at the same time. While this might seem a strange thing to do, it had a number of values and affordances that users liked. These included the appreciation of extra hidden content expanding on the print, hearing non-journalistic voices corroborating the stories, regional dialects making the paper more local, and the ability to multi-task across media channels by reading and listening to different elements simultaneously [3].



Figure 2. An interactive newspaper with printed buttons

## NEXT GENERATION PAPER

These investigations are typical of others in this area which have found various benefits to the augmentation of paper with digital information. They also use two core technologies which have been around for some time but are now coming into mainstream use. One is the use of image recognition in augmented reality applications which are able to superimpose digital information on (pictures of) the world. The other is printed electronics which is able to incorporate conductive inks, batteries and transistors on paper and plastic materials at an almost invisible scale. Image recognition is cheaper and more advanced than printed electronics for augmenting paper today, but printed electronics is more revolutionary in the long term. This is because it dispenses with the need for 'scanning' reading materials and gestures with a camera, allowing the paper to essentially sense these for itself.

These insights are the basis of a new project we are starting at the University of Surrey, in partnership with the Open University and a variety of industrial partners. The project is called Next generation paper and is funded by the Digital Economy programme in the UK (grant number EP/P02579X/1). We aim to generalise many of the lessons of the research community in this area, by defining two future generations of augmented paper based on image recognition and printed electronics respectively. We also plan to go beyond augmentation of paper with audio, as in the examples above, to allow video and other visual information to be displayed on a variety of internet appliances that happen to be nearby.

This leads to a vision of two future generations of paper connected to and augmented by the web. If today's ordinary paper is considered first generation (1G) paper, then 2G paper will be optically recognised with a camera, triggering associated digital information to be played or displayed on a nearby device. 3G paper will dispense with the camera and contain tiny sensors printed or embedded in the fibres of the paper itself. This will trigger the same kind of associations around it. In this way, paper documents and books could have hotlinks to webpages, audio, video clips and so on that could play on speakers or screens around them. The team will be looking at how this could change and connect the use of paper and screen-based information in tourism, where tourist brochures and guides already co-exist with mobile apps, digital photography and online booking systems.

A key feature of the project is that it will be investigating new business models for next generation paper, alongside building and testing the technology itself. This means that it will be working closely with its industrial partners on options for commercialisation and establishing industry standards

## BIOGRAPHY

David Frohlich is Director of Digital World Research Centre at the University of Surrey and Professor of Interaction Design. He joined the Centre in January 2005 to establish a new research agenda on new media innovation with social and cultural benefit. Current work includes a mixture of PhD and Research Council projects exploring digital storytelling, personal media collections and augmented paper. Prior to joining Digital World, David worked for 14 years as a senior research scientist at HP Labs, conducting design research on the future of mobile, domestic and photographic technology. David has a PhD in psychology from the University of Sheffield and post-doctoral training in Conversation Analysis from the University of York. He has also held visiting positions at the Royal College of Art, and the Universities of York, Manchester, Sydney (UTS) and Melbourne, and is founding editor of the international journal *Personal and Ubiquitous Computing*.



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