



## **Printing in a Digital Age**

Qian Lin, Jerry Liu, Daniel Tretter

HP Laboratories  
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### **Abstract:**

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# Printing in a Digital Age

Qian Lin, Jerry Liu, Daniel Tretter

Hewlett-Packard Laboratories

Paper has been used as an information medium for almost two thousand years. But during the past three decades, there has been a tremendous amount of growth in the number of digitally printed pages. Today, 200 billion pages are shifting to digital printing devices annually, driven by a number of fundamental changes in how people create, distribute, and consume content. Digital printers first came into their own as office and home printers, rendering documents and spreadsheets created by individuals on terminals and personal computers. In general, they are distinguished by their convenience (no manual prepress processes are necessary) and their ability to print 100% variable content economically. Modern digital printers range from portable personal printers, to office printers and copiers, to digital presses that are over 60 feet long and print at 400 feet per minute.

Today, people access a vast amount of information on the web, and printers are evolving from peripherals to Internet devices that can access the web directly and can themselves in turn be accessed via the web by other web-connected devices. This connectivity evolution significantly increases printer availability and ease of use. Moreover, this makes it possible to use cloud services to deliver content to users directly in hardcopy. With the growth in smart phones and the increased people mobility, there is an increasing need for people to access printers anywhere anytime. At the same time, content is increasingly becoming dynamic and multimedia. How dynamic content, accessed through devices such as iPad, can be made available in a variety of formats seamlessly requires new infrastructure for content delivery and fulfillment. Finally, the publishing industry is going through a major transformation, with high interest in personalization of published content as well as in micropublishing.

These changes in the content eco-system pose interesting challenges to the printer connectivity architecture as well as in content transformation and delivery. For example, on the connectivity side, we must make it easy for people to discover the nearest printers from a smart phone to send a print job. On the content transformation side, we need to provide a great print experience for web content as well as the software and services for people to design high quality content to express their creativity in personal, community, and business publications.

Will the use of paper as an information medium continue in the digital age? The answer is definitely “yes”. Information presented on paper offers significant improvements in readability, portability, and value over its digital counterparts. Equally important, there is tremendous value in paper being a tangible asset, capable of retaining information for generations to come. However, while the use of paper as an information medium will continue, the way it is printed will evolve. Newspapers, magazines, brochures, and many other types of content will be increasingly printed digitally. While a significant percentage of printed magazines never reach their readers today, the amount of waste can be dramatically reduced with digital on-demand printing technologies. Further out, the printed and the digital versions will go hand-in-hand, with the printed version serving as an index or guide to the vast amount of dynamic information on the web. An illustration of this is shown in Figure 1. The use of social media will continue to grow, and some of this socially created content will find its way to paper. New software and services will provide powerful tools for ordinary people to create content with high design quality. These new capabilities will democratize visual communications, making it easy for everyone, including school-age children, to create high impact materials for their communities and businesses. People will choose to use printed paper in conjunction with digital devices such as e-readers, smart phones, and laptops to communicate and share information, and to preserve memories, based on tasks at hand.

In this article, we'll discuss how printing has evolved in the digital age to adapt to the way people access content on the web and from smart phones, as well as the transformation in the publishing industry. We'll also show some examples of multimedia technologies in analysis and composition for printing applications.

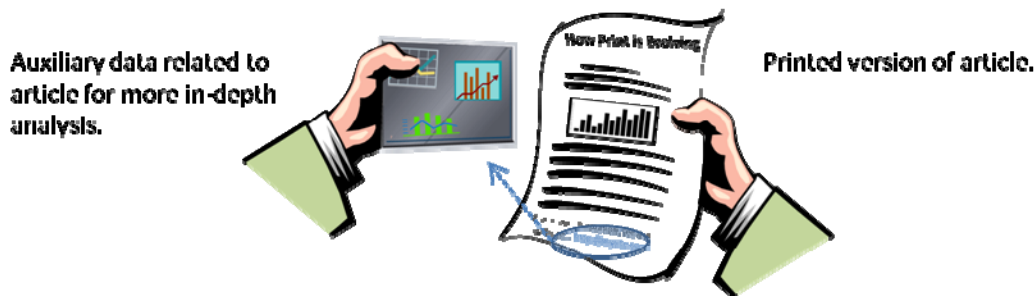


Figure 1: Printed version of an article can serve as a guide to rich sources of related digital materials.

## Printing and Web

The advent of the web has significant impact on consumer printing behavior. Whereas at one time office applications such as word processors and spreadsheets were responsible for generating most of the printed content, by late the 2000s, about half of the content printed at home and offices originated from the web. Yet, not all content is created equal. Although there is a wide variety of content being printed from the web, there are some contents that are printed more frequently than others. Internal HP studies have shown that some of the top categories of content that people print are maps, directions, articles, and recipes.

Most of the content printed from the web today originates from the web browser. The Internet Explorer team noted in a blog entry that an internal Microsoft study showed that printing is the second most used feature in the browser after navigation [1]. Despite the popularity of the print function, the technology for browser-based printing has not changed much since the advent of the original NCSA Mozilla browser. Minor optimizations aside, essentially browser printing is based on the WYSIWYG (What You See Is What You Get) principle. The browser renders into hardcopy whatever is displayed on the screen. Although this is a usable solution, the impedance mismatch of dynamic display and static hardcopy introduces a number of problems which most people with experience with browser printing would have experienced. One basic problem is in formatting. Some web pages have a fixed width that exceeds the width of the paper, causing content to be truncated. Many web pages are designed with main content taking up only a fraction of the width of the page, causing large blank regions in the final print and using extra paper. Even when formatting is not an issue, web pages often contain content that people are not willing to pay additional ink and paper costs to print, such as banner ads and navigation aids which often contain backgrounds with close to 100% ink coverage. And then there are contents not suitable for WYSIWYG printing such as videos, or web pages with dynamic content where it is not even clear what a user would want to have printed. The printing problems arising from the complexities of web content go on and on.

In general, popular solutions for these problems have come from the content providers. Sites which contain content meant to be printed, or sites large enough to support providing a printable version of the page, often provide a 'print' link which takes the user to a printable version of the content. A number of web content management platforms may offer a printable version of the page. However, providing a print version of web content usually entails additional cost for the content owner, and thus not all web contents come with printable versions.

In recent years, to address these issues, a variety of client-based solutions have appeared to help the users generate better prints. These solutions are often implemented as browser toolbars or bookmarklets and typically involve running software to post-process a web page to provide a version more amenable to printing. One of the well known examples comes from PrintWhatYouLike.com [2] which provides a bookmarklet or a browser toolbar for a user to edit the page before printing. Readability.com [3] is another service of this type which specializes in article type pages. A bookmarklet analyzes a web page for articles, and if an article is detected, the web page is transformed by deleting the extraneous content and only keeping the article content. The feature is now included in the Apple Safari browser. HP recently developed a state-of-art web analysis technology that is implemented as a 'Smart Print' button in a browser toolbar which automatically analyze content within a web page for print relevancy and automatically suggests regions to be printed [4]. The user is free to accept the recommended print regions or manually edit selected regions to arrive at the final print layout. One advantage of these client side solutions is that they do not

rely on the content provider to provide a print version. Also, the user is able to customize the print version as opposed to using the one provided by the content owner. The changes in the print quality can be significant from these tools. As an example of a user printing some product information on the hp.com site before heading out to the store, Figure 2 shows the default print preview of a product information page from Internet Explorer 7 on the left, and the output from the HP Smart Print technology on the right. The processed page on the right is more focused on relevant content while using less ink and paper.

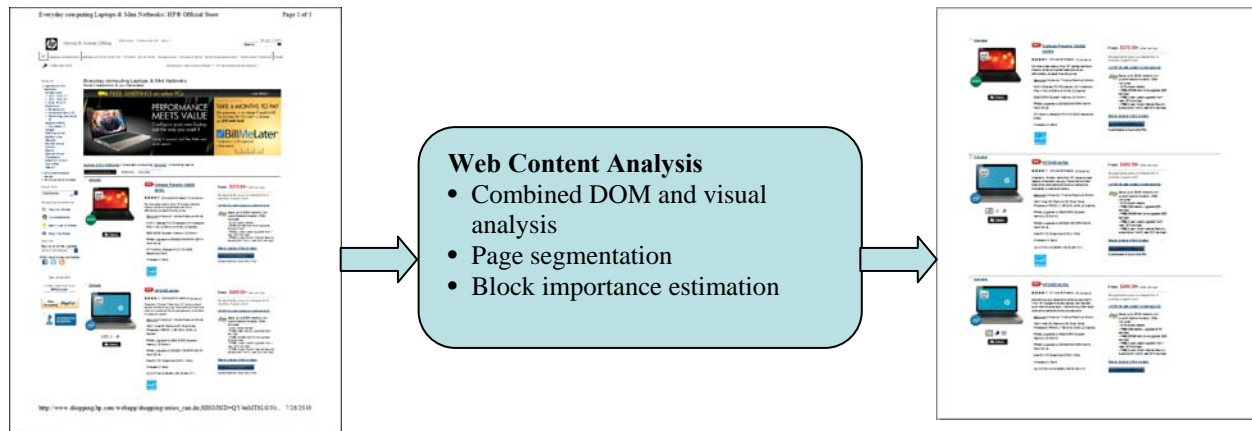


Figure 2: HP SmartPrint technology analyzes web content and help select content for print.

Another innovation that has appeared within the last year is the notion of web-connected printers. These printers have a control panel for user input and can directly connect to the Internet to retrieve web content to be printed, eliminating the need for the printers to be connected to a computer. Thus, these printers are now first class citizens on the Internet rather than being a peripheral device attached to an Internet connected device. In addition, these web connected printers can be customized by downloading various printing applications which run on the printer. Typical printing applications include ones that generate coloring pages, newspapers, or weather reports. The web-connected printers simplify the navigation required to access web content and reduce the errors introduced in formatting web content for print.

### Printing and Smart Phones

As smart phones, phones capable of running applications and connecting to the Internet, become more prevalent, more content is being consumed, and to a lesser extent generated, from these phones. In a recent survey conducted by HP, 85% of smart phone users have expressed interest in printing. However, printing from these mobile devices is generally not as straightforward as printing from traditional platforms such as personal computers. The printing difficulties arise from two main causes: connectivity and content. Modern printers come with support for wireless LAN, but if the smart phone is connected to the cellular data network, it becomes extremely difficult to establish network connectivity between the mobile and the printer. And for cases where network connectivity has been established, the lack of appropriate software drivers on the phone often prohibits the mobile device from making full use of the printer features.

To improve the connectivity issue from mobile devices, there are a number of solutions which rely on the presence of a PC based service to route jobs to the printers for cases when the phone cannot connect to the printer via a wireless LAN. However, these solutions do not typically appeal to a large segment of the population because of the setup complexity and the requirement that a computer has to be left on. Recently, HP has introduced a service called ePrint which assigns an e-mail address to the printer [5]. The users can then print from the phone simply by emailing the document as an attachment to the e-mail address assigned to the printer. The ePrint cloud service also solves the printer driver problem by performing rendering in the cloud, eliminating the need to do so in the printer or within the mobile device itself.

Aside from network connectivity issue, there may also be issues around content presentation. The content available on the phone may not be in the same form as the printed result that a user may wish to have. For instance, a user may have several dozen photographs captured by the phone camera and stored on the phone yet may not necessarily want to print a stack of 4x6 snapshots. Web surfers doing product research on the phone may wish to print information pages for later reference, but an abbreviated mobile version of the site may not be the more complete regular version that people want to print. Also, as is with the case of regular web printing from computers, most web pages contain navigation aids which most people do not wish to print. The small form factor of the mobile phone reduces the interactions available to adjust the print job as well. For example, when printing a spreadsheet on a personal computer, most people will review and adjust the print regions to make sure that the cells of interest are contained within the page boundary to avoid orphan columns or rows. However, making such adjustments before printing may be extremely difficult on smart phones with small screens and limited interaction capabilities.

One key to resolving the content problem is in content transformation applications to adapt the content available on the phone to a format and form factor suitable for printing. An example of this scenario comes from a common use of camera phones today: document capture. With the increased resolution of mobile phone cameras, it becomes practical to use them to capture documents as a replacement for traditional scanners. The new capability of web-connected printers allows print jobs to be e-mailed to the printer. In addition, smart phones provide the access to high speed 3G and 4G networks, as well as the flexibility to install applications. These capabilities make it possible to use a mobile phone to capture a document any time any where, and to obtain a processed image as if it is scanned. Figure 3 shows the image of a document captured with a smart phone on the left, and an enhanced image of the document on the right. Further, the processed document can be sent to a web-connected printer, which can effectively make a copy of the document. Another example comes from the situation mentioned earlier of a smart phone with a collection of stored photos. Rather than printing the photos as they are, there are apps available to transform the photo collections into content that is more print worthy such as a photobook.

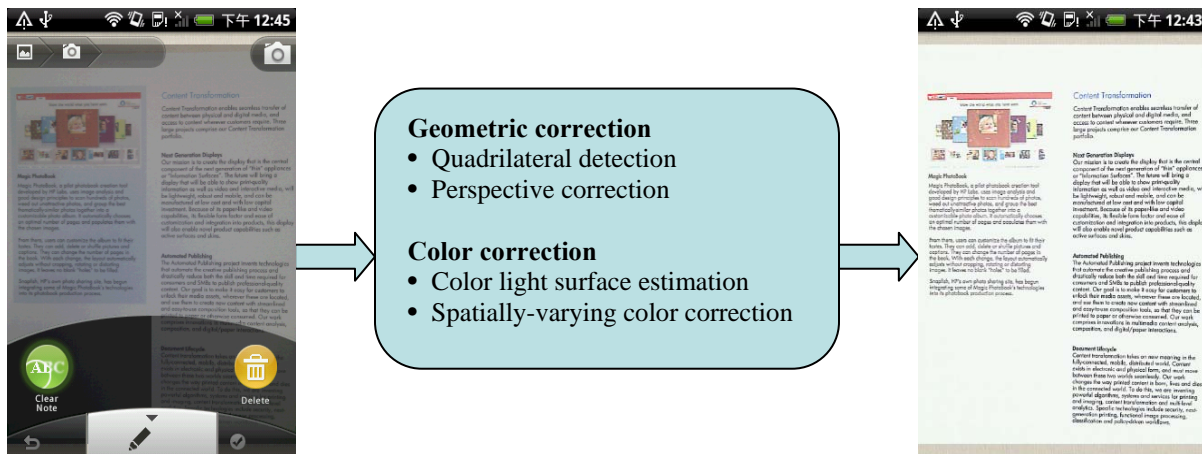


Figure 3: Using a smart phone as a scanner.

## Printing Gets Personal

As digital print evolves into an always-available resource that supports fully variable print jobs across the ecosystem, a variety of software and services are arising to take advantage of this new infrastructure capability. Studies have shown that people generally over value their own creations versus professionally created content [9], so many companies are pursuing opportunities based on giving individuals the chance to create their own content, then using digital printing to render the resulting outputs as micro-publications. The key ingredient is to provide software tools that permit untrained users to easily create high quality content of their own. This requires engineering intelligent tradeoffs between flexibility and ease of use, and a number of niche markets have already been developed to address this opportunity.

One of the first markets to exploit capabilities enabled by the emerging digital print infrastructure is photo merchandise creation. Personal photos are the ultimate in user-generated content, since they are unique artifacts reflecting important memories in a user's life. Photo merchandise uses this content to create personal publications like books, calendars, and collages. A number of companies provide desktop, retail and web-based software that enables untrained consumers to create high quality merchandise from their own photos. These solutions include web-based creation services as well as desktop-centric software. The demand for this type of micropublishing is clear, as photo merchandise is one of the most rapidly growing market segments in printing, with the US market expected to grow from \$1.1 billion in 2009 to \$2.2 billion by 2014 [11].

However, the solutions serving this market are far from mature, and many users are frustrated by the difficulties in creating such products. There are significant research opportunities in software and cloud service to address these frustrations by using sophisticated photo content understanding, collection analysis and interactive composition engines. These technologies allow the solutions to automate many of the time consuming steps and provide recommendations that enable users to create high quality products faster and easier, and can also be used to enhance the sharing experience. For example, an automatic photobook generation system was developed using content-based and context-based image analysis [6]. Web content can be added to a photobook to make the story-telling more compelling [7]. The experience of preserving and sharing memories on paper can be enhanced further by linking with digital content [8]. HP Labs' online research prototype, AutoPhotobook [12], makes it easy for people to create a photobook by automating the image selection, pagination, and layout. Analysis technologies like face recognition, theme clustering, and duplicate detection can be used as the basis for content recommendations and sorting. Figure 4 shows an example of how analysis technologies can be used to automatically populate a photobook from a folder of photos.



Figure 4: Using photo analysis to automatically create a photobook from a set of photos.

Composition technologies such as HP's BRIC engine can create high quality custom layouts that conform to selected content automatically, ameliorating many problems that typically occur when editing multi-photo products. Figure 5 illustrates how BRIC adapts to changes in content selection.



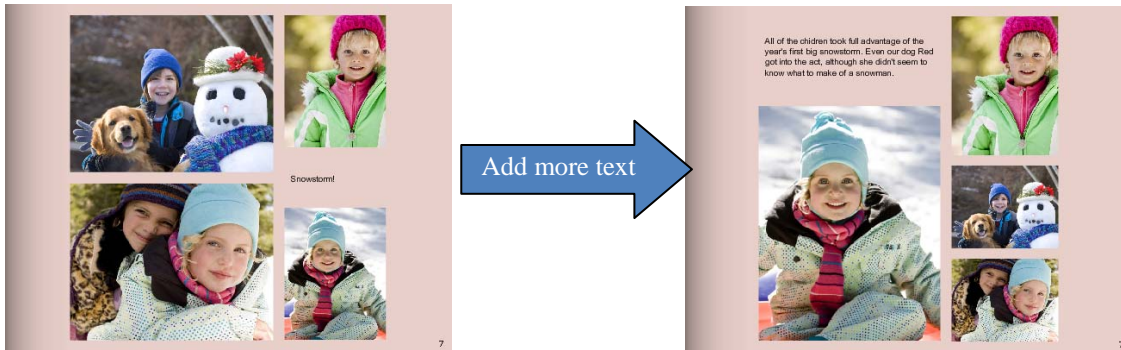


Figure 5: Generative layout algorithms can adapt to page content automatically.

Also, as consumers rely ever more on mobile devices as their preferred web and multimedia access mechanisms, photo merchandise creation solutions are beginning to move into mobile environments as well. Figure 6 shows the screen shot of a research prototype for creating photobooks on an iPad.



Figure 6: Photobook authoring application on an iPad.

Other companies have been starting to address micropublishing opportunities in book and magazine creation. Sites like Blurb provide rich editing and creation tools for books, tied to fulfillment and distribution based on digital print technology. Sites like Lulu and MagCloud concentrate primarily on the fulfillment and distribution end, but all of these solutions face a large barrier to growth due to the difficulty of creating enough high quality original content to fill a book or magazine.

Some companies are addressing this issue by focusing on providing pre-authored content in smaller “bite-size” chunks that an end user can mix and match, possibly with some of their own content, to create a custom micro-publication. Lonely Planet offers users the chance to create custom travel books by selecting and combining individual book chapters to match their interests and itinerary. Other companies offer professors and teachers the opportunity to create customized textbooks by selecting content from a large catalog for inclusion in their book [10]. CeWe offers users the opportunity to integrate relevant web content into personal photobooks, automatically selecting appropriate content to complement a user’s photos. This approach of enriching photobooks with content from the web has also been explored [7]. As this market continues to evolve, a key challenge will be to develop new, streamlined architectures to enable easier content creation/selection and composition. Only when this challenge has been successfully met will the full promise of micropublishing finally begin to be realized.

## Printing Meets Multimedia

Traditional media, such as books, magazines, and television, have been delivered through analog channels. During the past decade, broadcast TV has become digital, and increasing TV and movie content are available through the internet. On the other hand, books and magazines are still predominantly printed on analog presses and distributed through physical channels. Within the last few years, there has been a significant shift in the interest from the publishing industry to deliver content both digitally as well as through print. Many publishers are now creating magazine apps on iPad, for example.

One interesting trend for premium content on iPad is that the content is organized into pages that can be “flipped”, much like the traditional media such as books and magazines. This is very different from how content is presented on web pages, where content is hyper-linked. The new approach to content presentation provides a much better reading experience. As a result, content owners are experimenting with a subscription-based business model, in addition to the advertisement-based business model.

The digital versions of popular magazines include significantly more multimedia content such as photos and videos as compared to the printed versions. However, they often share the same articles, and in some cases, the advertisement with the printed version. We believe that the digital version and print version of magazines will co-exist, each offering unique benefits for readers. As the concept of books and magazines continues to evolve in the digital age, we expect the integration of animated and audio/video content to grow from a way to present auxiliary material into a primary part of the book or magazine. This integration will lead to closer linkages between the printed and digital versions of magazines, as a way to ensure that readers of the printed version can access the rich media content. Since rich multimedia is often experienced as a time-based medium independent of the pacing of a book or article’s own storyline, the incorporation of additional multimedia will eventually lead to more non-linear magazine and book consumption. In essence, the experience of reading a magazine or book in the future may well resemble today’s experience of playing video games, in that the user dynamically selects a path through the content that may differ substantially from the path taken by other readers. Of course, this will also substantially change the authoring experience, complicating the storytelling and editing tasks.

As an example of representing rich media content in the printed version, we show in Figure 7 how video content can be represented by an image collage. By analyzing motion parameters in a video sequence, we derive the camera movement as well as object movement [13]. We then create images representing video sequences that correspond to the capture intentions. For example, the video sequence captured during camera panning motion can be represented by a panorama image, and an action sequence can be represented by a number of image frames where the action takes place. When a video sequence is shot with the camera focused on a subject, we can use adjacent frames to construct a super-resolution image to represent the subject.

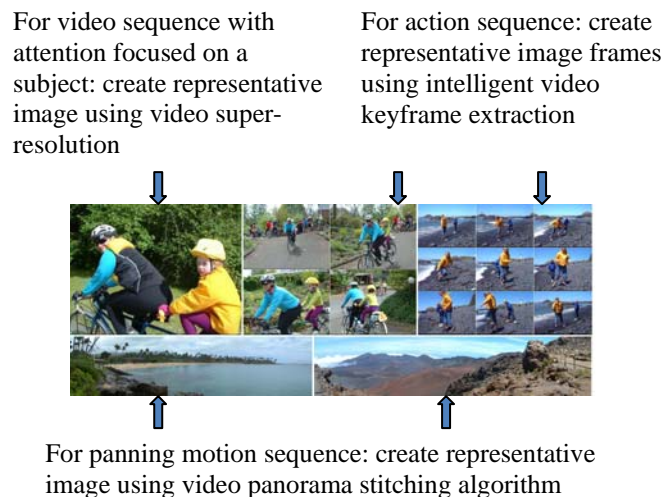


Figure 7: An image collage created from video.

In the coming years, a growing amount of printed content will include explicit or implicit linkages to dynamic digital content, often online. The printed content may serve as a summary or index into the digital content, acting as



the reader's guide to a rich multimedia experience. Printed content will still have the ability to stand on its own, but much of the value of printed materials may also come from their ability to serve as a signpost or nexus in a dynamic interconnected world of digital content. This use of print will link printed pages more closely to our personal and corporate lives, since they will serve as maps to our memories and professional repositories. In this way, prints will be ideal reminders, providing more detail than bookmarks or hyperlinks in a high quality, portable, and sharable way.

## Conclusions

Printing is becoming increasingly digital, and printing behaviors are evolving with how people consume content. As content is increasingly made available on the web and accessed from a variety of devices such as smart phones, transforming native digital content to print form requires many technology advances in multimedia content analysis, interaction, personalization, and composition. Although new digital content consumption devices such as tablets open up new channels for content delivery, printed content, with its inherent advantages in readability, portability, and permanence, will have a role in this new world. Printing in a digital age will continue to grow and adapt as it helps to drive a new ecosystem for content creation and content consumption.

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