

# Wetpaint: Scraping Through Multi-Layered Images

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## ABSTRACT

We introduce a technique for exploring multi-layered images by scraping arbitrary areas to determine meaningful relationships. Our system, called Wetpaint, uses perceptual depth cues to help users intuitively navigate between corresponding layers of an image, allowing a rapid assessment of changes and relationships between different views of the same area. Inspired by art diagnostic techniques, this tactile method could have distinct advantages in the general domain as shown by our user study. We propose that the physical metaphor of scraping facilitates the process of determining correlations between layers of an image because it compresses the process of planning, comparison and annotation into a single gesture. We discuss applications for geography, design, and medicine.

## Author Keywords

Touch Interface, Large Screen, Restoration, Visualization, Tangible User Interface.

## ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## INTRODUCTION

Multi-layered images are a convenient means to compact multiple views into a single two-dimensional display. In medical imaging, physical volumes are often visualized as a sequence of slices through the body. In archaeology, layers are used to depict temporal progression, whereas in architecture they help to design for spatial coincidence. In every case, the relationship between layers can be as telling as the individual images themselves, and it can be useful to compare one layer with another to determine persistence of features over time and space. Direct manipulation interfaces have been developed to assist in these tasks, but existing systems rely on either global or fixed point-based comparison between layers. Time-honored techniques from the domain of art diagnostics rely on free-form scraping to consider the most relevant samples when dealing with

multiple layers of information, as when restoring a painting. By translating the physical act of scraping through layers into a touch interface on a large screen, it can be possible to make fast and accurate comparisons of multiple layers in an image. We introduce a system called Wetpaint that is based on the technique of scraping to provide an insight into the spatial and temporal relationship between multiple layers of an image.



Figure 1. Multi-spectral scans of a painting (left); scraping through the layers of a painting using Wetpaint (right).

## ART DIAGNOSTICS

The preliminary phase of art restoration is diagnosis: an assessment of the historical condition of a work of art that helps to plan its exhibition and preservation. As with archaeology, the diagnosis of a painting consists of a layer-by-layer inspection of material deposited in a historical sequence. Traditionally, paintings are abraded with various tools that remove surface deposits, varnish and pigment to determine the order in which they were deposited. By carefully comparing the samples taken at each depth, diagnosticians can determine the relationship between the finished work and the original sketch, the process of painting and subsequent interventions.

Today, physical diagnosis is prefaced by multi-spectral imaging to ascertain the order in which materials were deposited on the artwork. Diagnosticians use specialized software to compare high-resolution scans at multiple wavelengths (i.e. infrared, ultraviolet, x-ray) in order to understand the painting's history (see Fig. 1). They compare the layers by adjusting their relative opacity [13].

Whether using a scalpel or a computer, a diagnostician considers only particular details of a painting at a time because different areas have varying significance and history [6]. Automated processing of the images can fall short when compared with direct manipulation interfaces that allow user-defined regions to be investigated [9,16]. Wetpaint has

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been designed to allow for arbitrary areas to be compared between multiple layers using the tangible metaphor of scraping, the hallmark of restoration.

### RELATED WORK

Many graphical user interfaces (GUIs) rely on a layered metaphor to organize multiple sources of information on a single display. Depth cues – such as shadows and occlusions – are commonly used to help organize the layers; these can facilitate reading and comparison of more than one layer at a time [16,18]. Drop shadows create the illusion of superposition in the layers of a GUI, and semi-transparent windows allow two layers of information to be viewed simultaneously [11,9]. But translucency is limited: high-frequency, low-contrast images can be hard to discern when superimposed [2].

Physical behaviors can make individual layers easier to organize, even when they have little contrast or when there are more than two. In one interface, application windows behave as pieces of paper that can be folded back to reveal underlying content [7]. In archaeology, where uncovering layers is fundamental, interfaces have been designed so that image layers can be peeled away from each other [3]. This provides an intuitive spatial arrangement of layers, but only allows users to view one whole layer at a time.

Focus-based interfaces make it possible to consider parts of an image differently than others. Some allow users to zoom into part of an image through a hand-held display or by image distortion, limiting the area of investigation to a pre-defined shape [1]. Some of these ‘lenses’ allow users to fade the opacity of a pre-defined part of one layer to facilitate comparison with another [14]. One museum installation allows users to uncover a mosaic by brushing away virtual dust on a touch screen [8]. Partially uncovering an image makes it possible to compare user-defined sections of one layer with surrounding context. Some Tangible User Interfaces (TUIs) allow users to deform the screen itself to create a pastiche of different layers. In one case, an elastic projection screen can be pushed and pulled in parts to reveal those sections of the adjacent stills of a video [5]. In another, the projection surface can be sculpted to reveal parts of multiple layers in a medical scan [15].

TUIs can facilitate navigation of three-dimensional spaces, such as multi-layered images, by employing simple physical metaphors and allowing users to have direct control [12]. Wetpaint employs a tangible metaphor to make arbitrary area comparison among image layers accessible for general use.

### DESIGN

Wetpaint is a touch interface that uses the physical metaphor of scraping to facilitate the process of exploring multiple layers of an image and determining their relationship. It was originally designed for an art exhibit, and subsequently made to work across various platforms. Users are presented with a large high-resolution image. When they touch the screen, the part of the image they touch is erased to reveal the layer

beneath. The ‘hole’ thus created has a jagged edge evocative of a paint chip with a drop shadow that reinforces the layer order (see Fig. 1). Dragging one’s finger over the screen removes the top layer; removing and replacing the finger allows the user to remove the subsequent layer(s). After sufficient inactivity the layers fade back in reverse order or “heal.” Healing is useful to bring out subtle differences between layers, similar to layer-fading diagnostic interfaces. Wetpaint also allows users to directly compare whole layers by touching page edges on the sides of the artwork to initiate a global fade to another layer.

While inspired by expert art diagnostic practice, Wetpaint was built to allow novices to undertake the study of a painting’s history on their own. It has since been developed to be studied for a variety of additional applications outside the art world, including geographic information systems (GIS), design and medical imaging. The interface is platform-independent, supports pictures of nearly any size and number of layers. A rich web application retrieves sequential images from a server (in our implementation, a Flash application retrieves images in a Flickr.com account). The interface works on any touch screen. We installed it on a 50” plasma screen with an infrared touch detection frame and a 20” drawing tablet and display; each interprets a single touch as the mouse pointer. A variable determining the size of scrape area is adjusted so that in each case, the area removed when scraping is just slightly larger than a fingertip. The whole system can be run locally or on a web browser, although a powerful graphics computer and local image storage are ideal for smoothly rendering multiple high-resolution image layers.

### EVALUATION

We conducted a pilot study to identify the benefits of our technique and a formal user study to measure the effectiveness of scraping in a specialized context.

#### Pilot Study

Our first evaluation helped to identify the benefits of Wetpaint as compared with existing means of visualizing multiple layers of information. We considered two cases: a two-layered map of a city and the subway lines beneath, and a five-layered image showing multi-spectral scans of a damaged painting. In each case we compared four ways of seeing the layers: 1) as adjacent images, 2) as a half-transparent composite, 3) with an interactive slider to fade through each layer, and 4) using Wetpaint. We asked users to name the subway lines under a street on the map, and how deep particular holes reach in the painting.

Five users (4 men, 1 woman, aged 20-30) participated in the pilot study. In every case, the interactive options (opacity fade and scrape) outperformed the static interfaces both in terms of accuracy and time, suggesting that direct manipulation is preferable to composite images. Adjacent images bear little frame of reference, and the half-transparent composite becomes difficult to read once there are more than two layers.

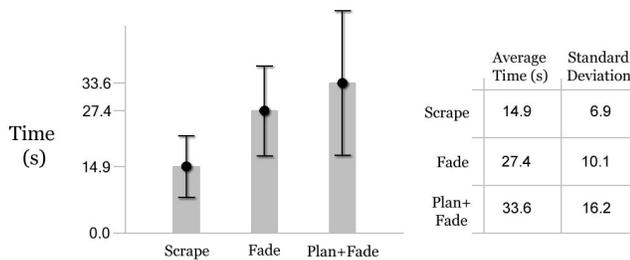
We observed some interesting behaviors with the slider-based fading and scraping interfaces that informed the design of the formal study. When using the slider to fade through image layers, some users would hold their other hand over a point of interest to act as a visual placeholder. This led us to hypothesize that scraping has advantages over fading if the area being investigated has an arbitrary or large shape – not just a single point or line.



**Figure 2. Our study compared scraping (left) with opacity fading using a slider (right).**

### User Study

We asked 14 individuals (11 men, 3 women, aged 20-35) to list the subway lines underneath a *particular path* through a city (e.g. North on 8<sup>th</sup>, East on 57<sup>th</sup>, North on Park) by comparing a satellite image of the streets to a map of the subway lines (see Fig. 2). Each user performed the same task by scraping through the layer (‘scrape’) and by using a slider to fade the opacity of the top layer (‘fade’). We measured the accuracy and duration of the task.



**Figure 3. Scraping performed faster than fading by 12 s. (19 s. when including the additional step of route planning).**

In terms of accuracy, scrape and fade performed similarly, suggesting that individual aptitude and the particular design of the map contribute more to accuracy than the choice of interface. In terms of duration, scrape was faster than fade for every user. They performed an average of 12.5 seconds faster when scraping through the layers as compared to fading between them with a slider (unpaired t-test,  $P < 0.001$ ). Half the users (7/14) used their finger to trace out the path on the map before using the slider, an intermediate step they skipped when they were able to directly trace the path on the image by scraping. When accounting for the additional time needed to plan out the path in the fade interface, users performed the task 18.7 seconds faster when scraping instead of fading through the image (unpaired t-test,  $P < 0.001$ ) (see Fig. 3). Wetpaint was more direct, as users only had to scrape the desired area once to peer beneath it, whereas they

would fade in and out an average of 2.7 times when using the slider to re-establish context. When asked for their preference, all of the users chose the scrape interface.

### Discussion

Though inspired by an expert practice, the tangible metaphor of scraping has benefits that could make it useful for general application. The technique has an advantage when comparing arbitrarily-shaped areas of different layers; it consists of the ability to simultaneously plan an area to be investigated, uncover it and leave a momentary annotation of the area. In other words, a user-defined ‘spotlight’ allows a freeform area to be uncovered and compared, and the path traced by scraping leaves an annotation of the area being examined. In comparison, the current diagnostic technique of controlled opacity fading requires two hands (one to toggle the opacity and one to mark the area of interest) and multiple gestures (fading back and forth to compare multiple areas). Since fading leaves no evidence of the points already compared, it could lead to redundant investigation. Most current interfaces also rely on a mouse, which could further slow down users by taking their gaze and/or hands off the screen.

Scraping through image layers can be compared to the use of ‘magic lenses.’ both allow details to be compared between layers, but only scraping allows a freeform area to be compared [4]. Sigma Lenses allow an area to be examined at a variable opacity, whereas Wetpaint only allows translucent comparison as part of the animated fading of the ‘healing’ effect [14]. Some users also pointed out that scraping is similar to the ‘eraser’ and opacity fading is akin to ‘layer transparency’ in common layer-based image and graphics software.

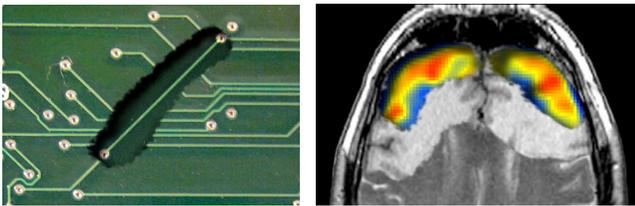
The technique of scraping is especially suited to the tasks in our study and in general when comparing arbitrarily-shaped regions of images. When a user does not know which area to investigate or when simply looking for any difference between two layers, global fading could be more desirable. In general, high-frequency images with little variation between layers could benefit more from a global comparison, whereas low-frequency images with high variability could benefit more from scraping.

Scraping can be inefficient for uncovering large areas. We have implemented a version where the ‘brush size’ of scraping grows with the speed of the finger, but there is a trade-off between accuracy and speed. Scraping is limited to a fixed layer order, and a way to shuffle the layers is necessary for many types of discovery. Scraping is also limited to a relatively small number of layers.

### Future Work

Wetpaint has been designed to work in a variety of contexts: our study explored applications in art and GIS; we have also produced some conceptual images of what the interface could offer in the domains of design and visualization (see Fig. 4). Our user study underscores the importance of

investigating a particular area without losing context or being distracted by surrounding information. In GIS, multiple layers of information can be overlaid, making it hard to read new information into maps that were designed for a single purpose. Scraping could make it possible to consider the topography of a particular political region on a large map, for example. In design, two-dimensional drawings must often be confronted to ensure the coincidence of services and structure. Someone planning an excavation could verify that there are no underground utilities in the precise area being considered. In medical imaging, two types of multi-layered images could benefit from scraping: serial images of the same area over time and slices of a three-dimensional volume, as in MRI scans. In both cases, it could be important to compare a particular area through multiple layers, determining change over time or persistence through depth. We will build a web-based tool that allows layer comparison between disparate images to be performed by experts and novices across a number of fields.



**Figure 4. Scraping through image layers could be useful in design (left) and visualization (right).**

## CONCLUSION

Wetpaint makes it easier to perform certain tasks by applying physical properties to digital images in ways that limit the attention load and provide intuitive comparison of arbitrary areas. The result is an interface which can be used to extrapolate useful relationships between layers that were not designed to be seen at once, enabling anyone to discover new patterns over space and time.

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## REFERENCES

1. Baudisch, P., Good, N., Stewart, P. Focus plus context screens: combining display technology with visualization techniques. *Proc. UIST 2001*, ACM Press (2001), 31-0.
2. Baudisch, P., Gutwin, C. Multiblending: displaying overlapping windows simultaneously without the drawbacks of alpha blending. *Proc. CHI 2004*. ACM Press (2004), 367-4.
3. Benko, H., Ishak, E. W., Feiner, S. Collaborative Mixed Reality Visualization of an Archaeological Excavation. *Proc. ISMAR 2004*. IEEE Computer Society (2004), 132-0.
4. Bier, E. A., Stone, M. C., Pier, K., Buxton, W., and DeRose, T. D. Toolglass and Magic Lenses: The See-Through Interface. *Proc. SIGGRAPH 1993*. ACM Press (1993), 73-0
5. Cassinelli, A., Ishikawa, M. Khronos projector. *Proc. SIGGRAPH 2005 Emerging Technologies*. ACM Press (2005), 10.
6. Grabczewski, E., Cosmas, J., Van Santen, P., Green, D., Itagaki, T., Weimer, F. 3D MURALE: multimedia database system architecture. *Proc. VAST 2001*. ACM Press (2001), 315-2.
7. Dragicevic, P. Combining crossing-based and paper-based interaction paradigms for dragging and dropping between overlapping windows. *Proc. UIST 2004*. ACM Press (2004), 193-6.
8. Dunn, R. The virtual dig. *SIGGRAPH 2002 Conference Abstracts and Applications*. ACM Press (2002), 122-3.
9. Harrison, B. L., Ishii, H., Vicente, K. J., and Buxton, W. A. Transparent layered user interfaces: an evaluation of a display design to enhance focused and divided attention. *Proc. CHI 1995*. ACM Press (1995), 317-4.
10. Huang, Y., Brown, M. S. User-assisted ink-bleed correction for handwritten documents. *Proc. JCDL 2008*. ACM Press (2008), 263-1.
11. Ishak, E. W., Feiner, S. K. Interacting with hidden content using content-aware free-space transparency. *Proc. UIST 2004*. ACM Press (2004), 189-2.
12. Ishii, H., Ullmer, B. Tangible bits: towards seamless interfaces between people, bits and atoms. *Proc. CHI 1997*. ACM Press (1997), 234-1.
13. Möller, C., Seracini, M. The third dimension of "Ritratto di gentiluomo". *SIGGRAPH 1996 Visual Proc.* ACM Press (1996), 11.
14. Pietriga, E., Appert, C. Sigma lenses: focus-context transitions combining space, time and translucence. *Proc. CHI 2008*. ACM Press (2008). 1343-52.
15. Ratti, C., Wang, Y., Piper, B., Ishii, H., and Biderman, A. PHOXEL-SPACE: an interface for exploring volumetric data with physical voxels. *Proc. DIS 2004*. ACM Press (2004), 289-6.
16. Sekuler et al. Perception, Fourth Edition. Boston: McGraw Hill, 2002, 331-51.
17. Shneiderman, B. Direct manipulation for comprehensible, predictable and controllable user interfaces. *Proc. IUI '97*. ACM Press (1997), 33-9.
18. Zhai, S., Buxton, W., Milgram, P. The partial-occlusion effect: utilizing semitransparency in 3D human-computer interaction. *ACM Trans. Comput.-Hum. Interact.* 3, 3 (Sep. 1996), 254-84.