Structured Layout for Resizable Background Art

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We have investigated a method to represent dynamically resizable background art images using a structured layout language. Background art is often used in photo layout to enhance the photo sharing experience, to impose a theme in story telling or to add better visual effect to photos. Different from natural scene photographs, background art images tend to have strong regularity and symmetry. Directly applying general resizing techniques to the whole image often fails to preserve the original design intention. By examining the background images that are manually composed for different page sizes by graphic artists, we have come up with a set of design theories. Based on these theories, we developed a design language and a transformation algorithm that together enable dynamic adaptation of images to different layout dimensions, while preserving the original look and feel. The design language describes the composition of a background with primitive image elements. Based on the attributes of the elements, the transformation algorithm dictates how each element should be resized and translated with the layout dimension. In our test cases, the automatically resized images give comparable results to manually resized ones. This method provides several benefits for automatic photo album layout: not only it adapts the art design to different page dimensions, it also automatically adjusts the photo placement regions, and it often allows the composition of large and high resolution images with relatively small number of image primitives.

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ABSTRACT

We have investigated a method to represent dynamically resizable background art images using a structured layout language. Background art is often used in photo layout to enhance the photo sharing experience, to impose a theme in story telling or to add better visual effect to photos. Different from natural scene photographs, background art images tend to have strong regularity and symmetry. Directly applying general resizing techniques to the whole image often fails to preserve the original design intention. By examining the background images that are manually composed for different page sizes by graphic artists, we have come up with a set of design theories. Based on these theories, we developed a design language and a transformation algorithm that together enable dynamic adaptation of images to different layout dimensions, while preserving the original look and feel. The design language describes the composition of a background with primitive image elements. Based on the attributes of the elements, the transformation algorithm dictates how each element should be resized and translated with the layout dimension. In our test cases, the automatically resized images give comparable results to manually resized ones. This method provides several benefits for automatic photo album layout: not only it adapts the art design to different page dimensions, it also automatically adjusts the photo placement regions, and it often allows the composition of large and high resolution images with relatively small number of image primitives.

Categories and Subject Descriptors

I.4.10 [**Image Representation**]: Hierarchical.
I.4.5 [**Reconstruction**]: Transform methods.

General Terms

Algorithms, Design, Languages

Keywords

Image resizing; image layout; image composition

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1. INTRODUCTION

Background art is often used in photograph layout to enhance the photo sharing experience, to impose a theme in story telling in a photo album or to add style and better visual effect to photos. Many photo sharing and photo album design sites provide such artworks [1, 2, 3]. Shown in figure 1 is a snapshot from Picaboo web site, where various background designs are provided for the "school" occasion. Usually, such artworks are prepared manually only for one or a few specific sets of aspect ratios by graphic artists using Adobe Photoshop or illustrator. The inflexibility of the layout limits the use of the theme art in different products or displays. It is often desirable to adapt the background arts to various page aspect ratios as shown in figure 2.

Figure 1: Snapshot from Picaboo website, where user can choose different background artworks for photography layout.

Figure 2. A sample shows background art and photo layout are automatically adjusted to photo books with different page dimension.

There have been some prior works on automatic image resizing. Seam-carving technique described in [4-6] was able to automatically resize the image to different aspect ratios by removing low energy paths. This approach works well for resizing natural scene photographic images. However, because background art often contains patterned graphic elements with strong regularity and symmetry, directly applying this technique to the whole image could introduce severe and obvious artifacts. Artistic resizing technique described in [7] requires designer to provide multiple versions of one graphic object, and then let the system interpolate its resizing behavior. This method targets user interface design. It doesn't address some of the more complex graphic objects in background art images, where page resizing sometime not only requires the scaling of the graphic objects but could also require addition, abstraction or synthesis of new graphic objects.

Previously we have investigated how to decompose a background art image to two types of primitive design elements, and recompose the image by scaling and translating individual elements based on their types [8]. In this study, we expand the previous work to cover more complicated artworks and types of designs and introduce patterned elements. The key contribution of this paper is the design theories we have come up with, motivated by various theme art samples created by graphic artists. It consists of the abstraction of types of design elements used in background arts, and their layout rules. The type of an image element defines its scaling behavior. The layout rules define the transformation algorithm of an image element based on its type, style and layout position. It dictates how each element should be scaled and translated with page dimension. An XML language is used to describe the composition of a theme art. It lists the image elements and associated attributes. It separates the content of the image elements from style and layout therefore allows the reuse of content. Sometimes, a large and high resolution image can be composed with relatively small amount of image primitives. The XML language and the transformation algorithm enable background designs to adapt to different page dimensions, while preserving the design intention. It also orchestrates relative positioning of design elements with the photo placement region by computing a new allowable photo layout region for the new page dimension. This method works well with adaptive photo layout [9-11] as a new photo collage can be created based on the new photo layout region. In the following section, we will describe design theories and the composition language in detail.

2. METHOD

We have examined over 100 professional designed background art images from various photo album creation websites [1-3] and from our internal graphics designers. Among them, twenty three have been prepared for two different page dimensions. From those samples, we came up with the following design theories. Based on those theories, a design language and an associated transformation algorithm are developed to automatically adapt the background designs to different page dimensions, while preserving their original look and feel.

2.1 Design theories

Types of image objects: Background artworks are mainly composed by three types of image objects or primitives: *stretchable, non-stretchable and extensible*. Stretchable elements are freely scalable without a fixed aspect ratio; non-stretchable elements can only be scaled with a fixed aspect ratio. Extensible elements are patterns, when resizing, additional similar patterns may be added, subtracted or re-synthesized. Samples for stretchable, non-stretchable and extensible elements are shown in Figure 4, 5 and 6, respectively.

Image objects' layout rules:

- In a photo album, photographs are often placed in the center of the page and decorative design elements are placed around the photographs and towards the edge of the page. During resizing, relative positions of design elements to the edges of references need to be preserved.
- The best starting dimension for a design is square. It is the isotropic state. From the square, resizing to the landscape and portrait layout yields equal visual balance effect.

The layout rules for each type of elements are described in formulas in the following section.

2.2 Layout Language

The composition of a theme art is implemented through a design language and an associated transformation algorithm. The design language is an XML description of the layout composition. It includes a list of page elements. For each element, there is a content object and an array of attributes, such as type, style, geometric layout position and possibly its position relative to the others. The transformation algorithm takes element's attributes into consideration and dictates how each element should be scaled and translated on a page during resizing.

The content object of an element is an artistic illustration usually in an image or vector graphics format. An element's type defines how it can be scaled during page resizing. Figure 3 shows the detailed structure of element types. At top level, we have three major categories: stretchable, non-stretchable and extensible.

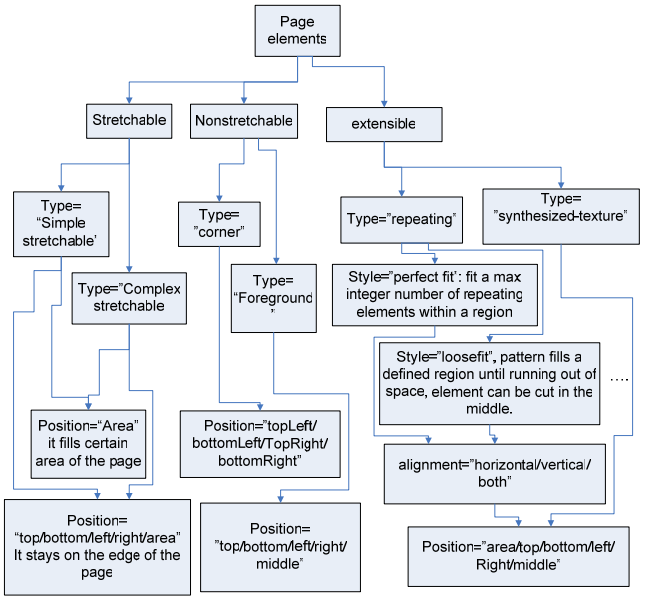

Figure 3. Overview of the layout language structure

2.2.1 *Stretchable Elements:*

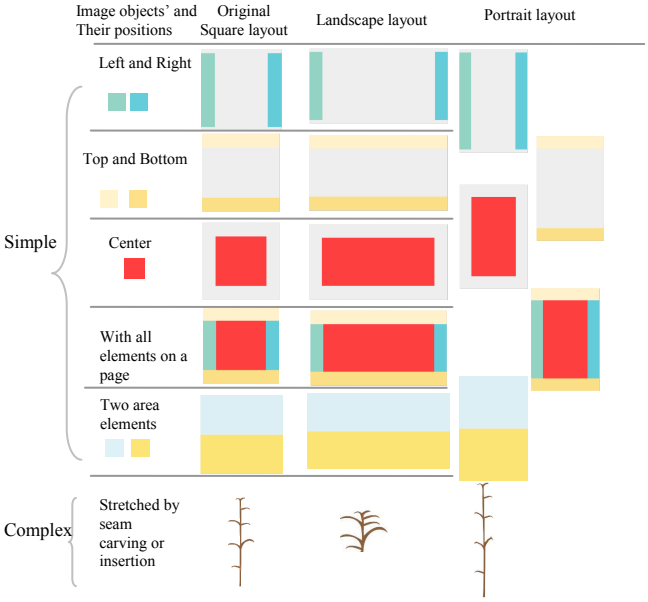

Figure 4. Page with various stretchable elements resized under different conditions.

Stretchable elements are ones that can be resized without a fixed aspect ratio; the stretchable type is further categorized into "simple" and "complex" one. A simple stretchable element can be scaled in horizontal and vertical direction to achieve required dimension. A typical example of such elements is a solid colored rectangle. A complex stretchable element requires more sophisticated methods to resize such as "scale9" [12] or "seam carving or insertion" technique [4-6] with defined constrains. For example, a picture frame with even thickness around four sides is a complex stretchable element which can be scaled using "scale9" to preserve the evenness of the frame; an illustration of a tree with different branches is a complex stretchable element which can be scaled with "seam carving" technique to grow the branches without distortions. The type and the position of an element on the page decide its layout constraint. For a stretchable element, position as "area" means the element covers part of the page, resizing constraint is that width and height of the element are always scaled proportionally to the width and height of the page; a position as "left", "right", "top", "bottom" or "middle" means the resizing constraint is to preserve the relative distance to the referenced edge of the page indicated by the position attribute. Assuming the original design is in a squared page with width and height of $l0$, the shortest distance from edge of the element's bounding rectangle to the left, right, top and bottom of the page is $\delta L0$, $\delta R0$, $\delta T0$ and $\delta B0$ respectively and the element's bound box is $\varepsilon w0$ X $\varepsilon h0$. If the new page width and height are w *and* h; δL, δR, δT and δB are the new distances, and the new element's bounding box width and height are εw X εh the layout rules are:

For position="top": $\delta T/\delta T0=\delta L/\delta L0=\delta R/\delta R0=\varepsilon h/\varepsilon h0=min(w, h)/l0;$
For position="bottom": $\delta B/\delta B0=\delta L/\delta L0=\delta R/\delta R0=\varepsilon h/\varepsilon h0=min(w, h)/l0;$
For position="left": $\delta L/\delta L0=\delta T/\delta T0=\delta B/\delta B0=\varepsilon w/\varepsilon w0=min(w, h)/l0;$
For position="right": $\delta R/\delta R0=\delta T/\delta T0=\delta B/\delta B0=\varepsilon w/\varepsilon w0=min(w, h)/l0;$
For position="middle": $\delta T/\delta T0=\delta B/\delta B0=\delta L/\delta L0=\delta R/\delta R0=min(w, h)/l0;$

Figure 4 illustrations how different stretchable elements are reshaped and repositioned for pages of different aspect ratios.

2.2.2 *Non-stretchable elements:*

Non-stretchable elements are ones that can only be scaled with a fixed aspect ratio. Non-stretchable elements are usually identifiable objects with specific semantic meanings. They can be further categorized as "corner" elements whose placements follow corners of the page and foreground elements which are placed around the edges or in the middle of the page. Scaling of such an object needs to preserve its original aspect ratio. As with stretchable elements, the placement of the non-stretchable element in a new page is based on its position attribute and is aimed at preserving its relative position on the page. For a "corner" element, that is to preserve its relative distance to the corner indicated by the position attribute. For a "foreground" element, in one axis, it is to preserve its distance to the referenced edge as indicated by its position attitude; in the other axis, is to preserve the ratio of its distances to two opposite edges of the page. Again, using the same notations as in Section 2.2.1, the layout rules for a non-stretchable element are:

For all non-stretchable elements: $\varepsilon h/\varepsilon h0=\varepsilon w/\varepsilon w0=min(w, h)/l0;$
In addition,
For "corner" elements:
For position="top Left": $\delta T/\delta T0=\delta L/\delta L0==min(w, h)/l0;$
For position="top Right": $\delta T/\delta T0=\delta R/\delta R0=min(w, h)/l0;$
For Position="bottom Left": $\delta B/\delta B0=\delta L/\delta L0=min(w, h)/l0;$
For position="bottom Right": $\delta B/\delta B0=\delta R/\delta R0=min(w, h)/l0;$

For "foreground" elements:
For position="top": $\delta T/\delta T0=min(w, h)/l0\ ;\ \delta L/\delta R=\delta L0/\delta R0;$
For position="bottom": $\delta B/\delta B0=min(w, h)/l0\ ;\ \delta L/\delta R=\delta L0/\delta R0;$
For position="left": $\delta L/\delta L0=min(w, h)/l0\ ;\ \delta T/\delta B=\delta T0/\delta B0;$
For position="right": $\delta R/\delta R0=min(w, h)/l0;\ \delta T/\delta B=\delta T0/\delta B0;$
For position="middle": $\delta T/\delta T0=\delta B/\delta B0;\ \delta L/\delta L0=\delta R/\delta R0=min(w, h)/l0;$

An example of a page composed by various non-stretchable elements is illustrated in figure 5. It shows how the non-stretchable elements are positioned on pages with different aspect ratios.

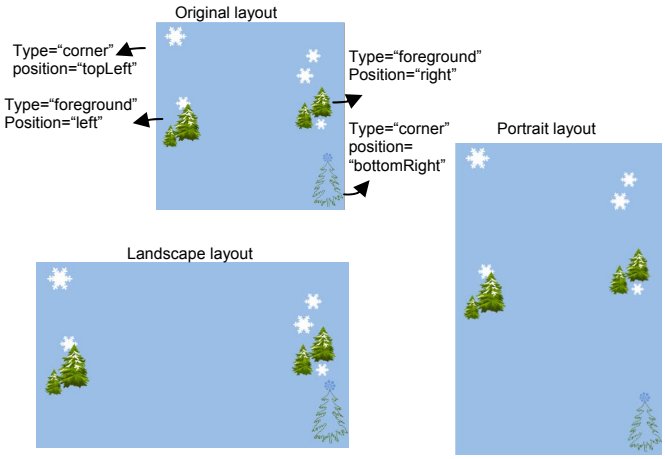

Figure 5: A page composed of several non-stretchable elements

Extensible elements are patterns, when resizing, additional similar patterns may be added, subtracted or re-synthesized. The extensible type is further categorized as "repeating texture", a pattern simply repeating over a certain area on the page; and "complex texture", a texture with certain randomness in the design such that resizing requires synthesis. In Figure 6, examples are given for pages composed by simple and complex texture. The layout rules for extensible elements are as following: the scaling of individual patterns that form the texture is similar to non-stretchable elements, they are scaled with a fixed aspect ratio; the area that needs to be filled by the texture is calculated as for stretchable elements, obeying the same layout constraints. Repeating texture elements have additional attributes such as "style" and "alignment" that determine how the repeating elements fit into the defined region. As indicated in Figure 3, if style="perfectFit", the system is to fit a max integer number of repeating patterns within a given region at an even spacing between elements; if style="loosefit", patterns are placed next to one another within the defined region without a gap until it runs out of space. In this case, an element can be cut in the middle by the edge of the region. Alignment attribute defines the orientation of the elements' placement, e.g. vertically, horizontally, or both; There may be more styles or alignments in fitting patterns into a certain area. For an extensible element, the content object may have multiple candidates. One of the candidates can be chosen randomly when placed on the page.

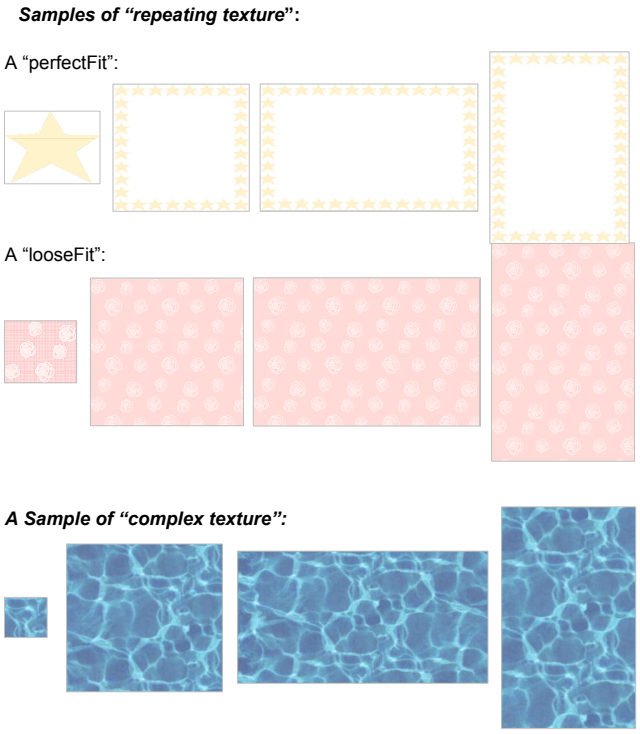

Figure 6: Samples of extensible elements. On the top are repeating texture and at bottom is a complex texture fitting into different paper sizes. For each sample, from left to right are "pattern element", texture in "square" layout, in "portrait" and "landscape" layout.

In addition to elements and their placement types, additional information used for content layout can also be specified through the design language, such as an active photo and text layout area on the page, which is usually chosen to not occlude important background elements. The active layout area can be defined in sizes of the 4 margins, or in distances relative to specific design elements. It is scaled and calculated appropriately based on the design elements positions on the page.

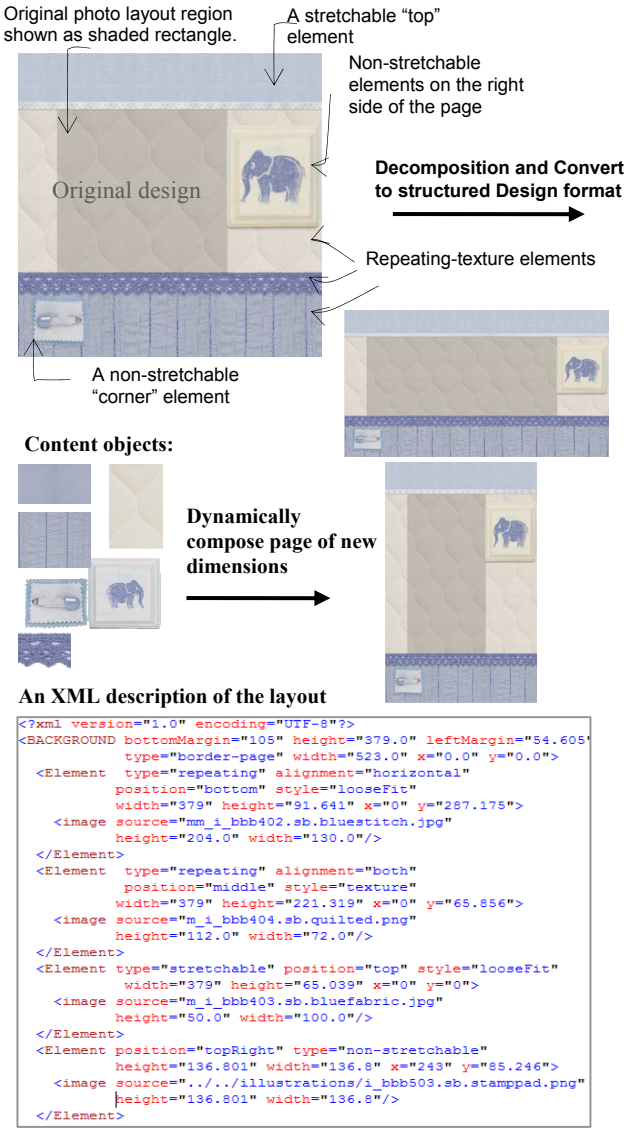

Figure 7. A sample background image with various types of elements.

3. Putting the design language into practice

We have decomposed and converted over 40 professional theme art designs to our structured XML design format. An example of this process is shown in Figure 7. Additional samples are shown in Figure 8. Different design elements on the page are identified, segmented, and assigned with appropriate attributes. Individual design elements are extracted as "content objects". Redundant

content objects can be eliminated, and common content can be shared among different elements to reduce the size of the design.

A user study was performed using 18 designs which have been laid out for two different aspect ratios by graphic artists, a square layout and a landscape layout of 11.25 x 8.5. Based on the square layouts, we created XML descriptions of the designs and automatically resized them to the landscape layouts based on our method. We asked ten users to rate the auto-resized layouts and the artist-resized layouts based on visual appearance and usability. The "no-difference" trials were evenly split between the "artist-better" and the "auto-better" groups. The proportion of "artist-better" trials were 0.48, slightly lower than the "auto-better" group, but the difference is not significant (two-sided binomial test, 180 trials from 10 subjects and 18 designs, $p>0.05$). Therefore, the auto-resized theme art images give comparable results to manually ones.

4. Conclusion:

In this paper, we described a design method for photo album theme art. It is based on a set of design rules. This method provides several benefits for automatic photo album layout: it not only adapts the art design to different page dimension, it also automatically adjusts the photo placement region, and it often allows composition of large high resolution images with relatively small numbers of image primitives. This method has been integrated into a photo album system to create personalized photobooks.

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Figure 8. Samples of structured background images resized to different aspect ratios.