Living Windows: a new material for storytelling

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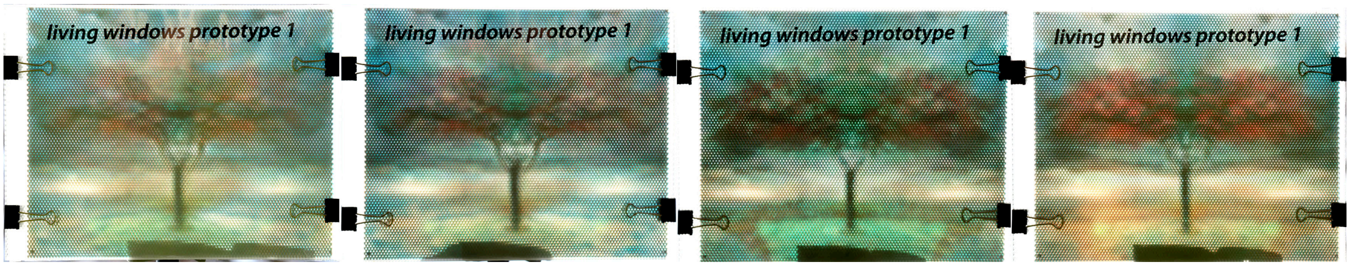

Figure 1 Living Windows are used to depict a tree blossoming over the course of a day.

ABSTRACT
We introduce a new material for dynamic storytelling. The material acts as a pixel-addressable display dependent on the environment lighting. Placed in a window, it conveys rich stories based on the time of the day or the season. Our material is completely passive and can be used in a similar fashion to stain glass windows.

Keywords
Storytelling, new materials for creativity, stained glass, windows

INTRODUCTION
Stained glass has a thousand year history in art and craft applications on windows of churches, buildings and people's houses. Stained glass windows display both abstract and figurative narratives often drawn from the religion, history, and literature. A traditional narrative window consists of panels that relate a story.

Traditional stained glass windows depict 2D static images using a patchwork of colored glass pieces. The glass pieces are put together with H profiles made out of lead and soldered into place. Details, as shown in Figure 2, are painted on the glass. Painting glass evolved whereas it was less labor intense than creating a patchwork.

Stained glass storytelling takes place spatially over multiple panels, whereas in the last century pictorial storytelling in time emerged with motion pictures.

We introduce a new material that we call Living Windows, a translucent material that can change color over time, depending on the incoming light. The material consists of a sheet of microlenses that color the incoming light in a pre-computed way. Placed on a window, the picture can change throughout the day when the sun moves from east to west, and over the year whereas the sun's elevation changes.

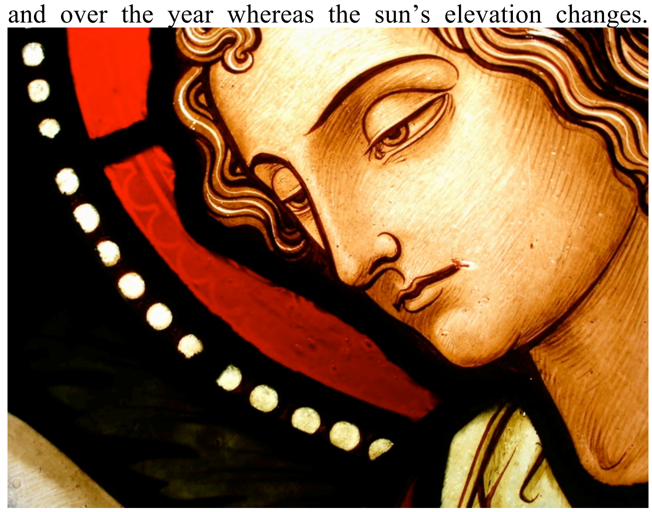

Figure 2. A traditional stained glass window consists of colored glass and painted details.

Calculating the path of the sun on a specific geographical location and heading used to be quite an effort. However today's cell-phones often include digital compasses and GPS, which makes determining the location and heading, and thereby the path of the Sun an easy task.

RELATED WORK
Microlenses and lenticular lenses have been around for a while [2] and are used depicting viewing angle dependent imagery. Fuchs et. al. [1] developed a 6D display. This display is viewer dependent and dependent on the incoming light direction.

TECHNOLOGY

Living Windows consist of a sheet of lenticular or microlenses, and in each row or pixel a number of images are encoded in similar fashion to a traditional viewer dependent dynamic images. In contrast to viewer dependent displays, the lenses are back-facing the viewer and direct the light to a specific subpixel. When this occurs, the light from the sub pixel illuminates the entire pixel through the diffuser.

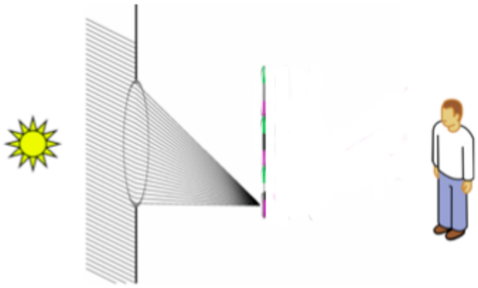

Figure 3. A microlens steers incoming light to a specific subpixel, and through a diffuser, colors the pixel.

For a specific geographical location we can calculate the path of the sun over the year, as depicted in Figure 3. The lenses steer the incoming light within a 90-degree field of view and can encode both the time of the day and the time in the year. The time between the summer and winter equinoxes overlap.

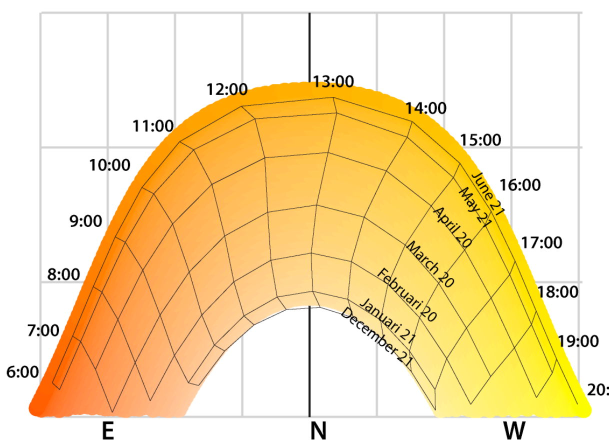

Figure 4. The path of the sun over a year calculated for a specific location. On the vertical axis the elevation and horizontally the heading.

MAKING

Our material comes in two variants. The simple variant consists of lenticular lenses that change color. On a north facing window, aligned horizontally will change color during the day, aligned vertically the color change will change with the season. On non-north facing windows the lenticular lenses should be rotated according to Figure 3.

The complex variant makes use of microlenses that encode the incoming light in two directions. Then based on a specific location/heading we can encode an image during the time of the day and season.

Our prototype is built with of-the-shelf sheets of microlenses and the image is printed on a transparency with a regular 300 DPI printer. The dot pitch of the lenses is 0.09 inch and we decode 24 by 24 images. Our diffuser consists of translucent tracing paper.

Our Instructables site [link omitted for anonymity], further details the process of creating a Living Window.

EXAMPLES

Our example as shown in Figure 4, shows a tree that blossoms over the course of the day. Other examples include displays that show special images for the winter or summer solstice or even digital clocks and calendars.

DISCUSSION

The Living Window is an easy-to-use storytelling medium that brings the ancient art of stained glass windows into the modern world through windows that intelligently react to the light passing through them in novel ways. Living Windows can be easily deployed in a wide range of residential and commercial applications, including temporal art installations, passive digital sundials and calendars, light-adaptive passive lighting and many others.

Limitations

Printer resolution limits the number of subpixels that can fit beneath a given microlens pixel. The number of subpixels directly corresponds to the maximum number of possible views that pixel can present.

The angle of the window and altitude of the sun determines the portion of the day that the microlenses accept incoming direct illumination. In the northern hemisphere, during the time period starting on the Summer solstice and ending on Winter solstice, a north-facing window will accept angles plus and minus 45 degrees from north, but as windows face further away, they will from north will tend to receive, on average, less light throughout the year as well as lower light angles. A south-facing window in the same location may not receive any direct illumination. Changing the window direction also requires recalculating the subpixel arrangement. Essentially, if the sun is positioned outside the microlenses' field of view, then light will bleed into adjacent pixels.

ACKNOWLEDGMENTS

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