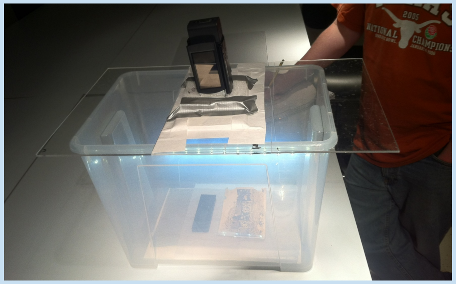
More than Meets the Eye: Eularian Video Magnification Applications for Conservation Research

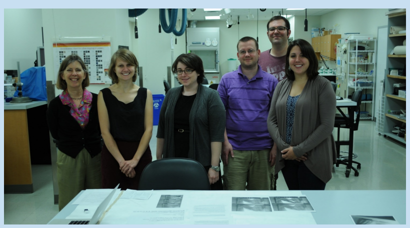
Karen L. Pavelka, pavelka@ischool.utexas.edu
Lorrie Dong, Artemis Harbert, Michael Nugent, Benjamin Philbrook, Elizabeth Seiple (School of Information)
Sarah Hunter (School of Architecture)
The University of Texas at Austin

Introduction

Eularian Video Magnification (EVM), a technique and tool developed by The Massachusetts Institute of Technology Computer Science and Artificial Intelligence Laboratory and Quanta Research Cambridge, Inc., allows researchers to view movements that are not visible with the naked human eye. Through EVM, researchers can apply spatial decomposition and temporal filtering to video sequences to amplify subtle variations in the signal. EVM was developed for non-invasive medical monitoring (e.g., determining pulse rates and respiratory motion), but may have some useful and exciting applications in conservation. Using high-definition (HD) video in conjunction with EVM, we were able to capture subtle movements across sheets of several types of paper.



A humidity chamber was constructed of a deep bin with a hole for the video camera cut in the lid. LED strip lighting proved to be most effective. In this image, a photograph and a hygrometer are inside the chamber.

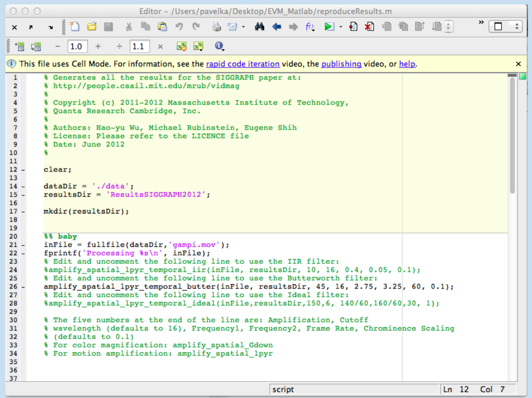


Left to right: Karen L. Pavelka, Elizabeth Seiple, Artemis Harbert, Michael Nugent, Benjamin Philbrook, Sarah Hunter. Not pictured: Lorrie Dong.

Research objectives

Could EVM, which was developed for medical purposes, be adapted for the linear movement one sees in paper expansion and contraction? Our goals included:

- To discover if the expansion and contraction of paper in relation to fluctuating relative humidity could be captured visually.
- To establish what the best parameters would be for capturing movement in paper.
- To work with inexpensive and easily available equipment.




```
% Generates all the results for the SIGGRAPH paper at:
% http://people.csail.mit.edu/mrub/vidmag
%
% Copyright (c) 2011-2012 Massachusetts Institute of Technology,
% Quanta Research Cambridge, Inc.
%
% Authors: Hao-yu Wu, Michael Rubinstein, Eugene Shih
% License: Please refer to the LICENCE file
% Date: June 2012
%

clear;

dataDir = './data';
resultsDir = 'ResultsSIGGRAPH2012';

mkdir(resultsDir);


%% baby
inFile = fullfile(dataDir,'gampi.mov');
fprintf('Processing %s\n', inFile);
% Edit and uncomment the following line to use the IIR filter:
%amplify_spatial_lpyr_temporal_iir(inFile, resultsDir, 10, 16, 0.4, 0.05, 0.1);
% Edit and uncomment the following line to use the Butterworth filter:
amplify_spatial_lpyr_temporal_butter(inFile, resultsDir, 45, 16, 2.75, 3.25, 60, 0.1);
% Edit and uncomment the following line to use the Ideal filter:
%amplify_spatial_lpyr_temporal_ideal(inFile,resultsDir,150,6, 140/60,160/60,30, 1);

% The five numbers at the end of the line are: Amplification, Cutoff
% wavelength (defaults to 16), Frequency1, Frequency2, Frame Rate, Chrominence Scaling
% (defaults to 0.1)
% For color magnification: amplify_spatial_Gdown
% For motion amplification: amplify_spatial_lpyr
```

The IT staff at the School of Information downloaded the code and installed it on a dedicated computer in the conservation labs. They annotated the code to make manipulation of the elements simple.

This image is taken from a video of glassine as it humidified inside a chamber. The glassine had been conditioned to 50% before being placed in the chamber. The image is shown unmagnified on the left, and magnified to an amplification of 35 on the right. Note the dark "pop" near the center and the dramatic crease above it. The movement lasted only about one second.

Method

Our research methods were necessarily exploratory in order to evaluate the potential uses of EVM for conservation purposes. The first half of the study examined humidified samples as they dried. Later, we built a chamber with an opening to accommodate a video camera so we could record as the paper humidified. Glassine proved to be the most useful paper for the initial experimentation because it reacts so radically tochanges in moisture content.

In addition to glassine, we examined a wide variety of other papers, including kozo, gampi, lens tissue, handmade paper, machine made paper, book leaves, prints, and kraft paper. We also experimented briefly with channeled acetate negatives, flaking pigment, and parchment.

We found that proper lighting is the most critical factor, and we tried ambient light, transmitted light, and raking light from one side, both sides, top and bottom. We experimented with LED strips, flashlights, standing lamps, fluorescent light and photo floods.

For the first test runs we took advantage of the free Videoscope by Quanta Research found at http://videoscope.qrclab.com. It allows free uploads of HD videos no larger than 45MB, or about 20 seconds. The site offers three filters for parameter testing: Eularian color, Eularian movement and phase based motion. We worked primarily with the movement filter to establish appropriate amplification and frequency range. We installed the program on local computers to allow experimentation with longer videos. However, we kept test videos short; each one-minute test segment took more than an hour to process, and an 18-minute video took 25 hours to process.

Results

We found that an amplification of 35 and frequency range of .5 to .9Hz gave the best results for seeing movement in paper. Using these parameters, we were able to minimize the video "noise" and still capture movement not visible to the human eye.

A strong raking light produces the most useful results and we found the LED strips to be the most controllable. Positioning the light strips level with the object and having the light travel across the surface gave the best results. Transmitted light gave good detail on thinner papers.

It was somewhat surprising how uneven the movement was across paper. Glassine gave the most dramatic results and very sharp flutters or pops appeared at seemingly random times. The corners of mould made paper waved, and strong distortions appeared randomly across the surface of the paper.

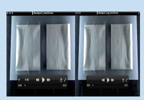
Future directions

EVM has the potential to be a useful tool for conservators, and while it does require some level of programming knowledge, we were able to achieve good results with a consumer grade camcorder. Possible applications include data to support recommendations for environmental conditions, predicting stress of hanging objects, and monitoring composite objects. We intend to further explore our work with paper and we invite collaborators.

Key to Video Demonstration: To view the movement of paper using EVM, see the Samsung tablet. (*Paired with poster at the conference.*) Four clips are looped into one video. In each case the original video is on the left and the magnified video is on the right. Pleae note: The original paper samples were all cut as squares, but multiple transfers between video formats has caused them to appear elongated on the Samsung tablet.

Original Magnified

Clip 1 (59 seconds)
This is a real time image of glassine as it humidifies in a chamber. In the magnified footage on the right, a strong wave starts on the right at 5 seconds and there is a dramatic pop at 57 seconds. There are a few seconds of noise at the end of this clip.

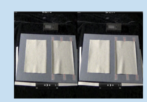


Original Magnified

Clip 2 (153 seconds)
Two pieces of mould made paper are on mat board, one hinged, one free. The samples were conditioned in a humidity chamber for 24 hours, then transferred to 56% RH. Raking light comes from LED strips positioned on the left and right. The original videos were time-lapsed by changing the iMovie setting from 100 to 500.

Original Magnified

Clip 3 (58 seconds)
The mould made paper sample was humidified for 24 hours, then moved to 69% RH. The iMovie setting was changed from 100 to 1000. The fluttering movement of the paper is erratic, starting and stopping at random.



Original Magnified

Clip 4 (71 seconds)
Two pieces of mould made paper are on mat board, one hinged, one free. The samples and board were conditioned in a humidity chamber for 24 hours, then moved to 20% RH.

Acknowledgements: We are grateful to Marci Colman, Systems Administrator, and Carlos Ovalle, Information Technology Coordinator, at the School of Information for guiding us through Matlab and for transferring the videos to the tablet.