Animated Paper: A Moving Prototyping Platform

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ABSTRACT
We have developed a novel prototyping method that utilizes animated paper, a versatile platform created from paper and shape memory alloy (SMA), which is easy to control using a range of different energy sources from sunlight to lasers. We have further designed a laser point tracking system to improve the precision of the wireless control system by embedding retro-reflective material on the paper to act as light markers. It is possible to change the movement of paper prototypes by varying where to mount the SMA or how to heat it, creating a wide range of applications.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. – Prototyping
General terms: Design
Keywords: Paper, SMA, flexible structure, Organic User Interfaces

INTRODUCTION
Personal computers have rapidly become lighter and more portable, making it increasingly easier to utilize computer displays or projectors instead of printed paper.

However, paper has many distinct advantages such as freedom in spatial manipulation, ease in face-to-face collaboration, lower interaction overhead, and disposability. Given these benefits, we will use paper as a prototyping material for developing and tinkering with new moving creations.

We are interested in the idea of moving paper because it brings us a new type of interaction with our physical world. We see this work as an opening to the larger issue of how to bring new functionality to everyday materials, particularly flat materials such as paper, cloth or film that may encourage people to think differently of their surroundings.

In this paper, we present "Animated Paper," a novel system which combines a computer control system with paper. We want to show that paper can be a playful material that encourages experimentation.

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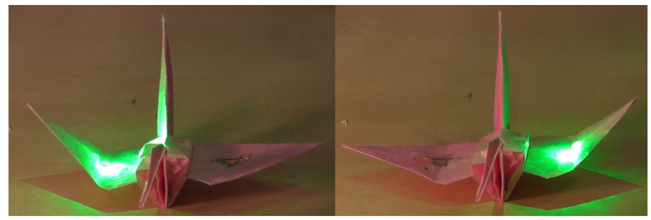

Figure 1: Animated paper

RELATED WORKS
Our goal is to create a new platform that can be easily understood and manipulated in order to help people regain their willingness and excitement in creating things with their own hands.

Currently, design thinking is a step-by-step process where first dirty prototypes are built with paper or clay, and then hardware prototypes are developed using Arduino or similar prototyping tools. Topobo[1] fuses these two steps by using module design, but is limited by the range of shapes that can be achieved. Our method is more flexible because it uses easily malleable components.

DESIGN
Our platform utilizes Bio-Metal, a fiber form actuator made from an extremely light and flexible SMA that can be easily bound and removed from paper, allowing for quick and cost-effective prototyping. When heated, the SMA mounted paper shrinks and bends, and has a quick retraction time. It is possible to change the movement of the paper figure by varying where the SMA is mounted, how it is heated, how the paper is held, the type of paper used, and also the length of the SMA, creating a wide range of applications. Because of the ease of copying and printing paper designs, it becomes very easy to reproduce and modify physical prototypes remotely.

SYSTEM
We use a Diode-pumped solid-state laser (Changchun New Industries, MGL-Ⅲ-532). The wavelength is 532[nm] and the power is 50[mW]. The laser passes through a half mirror (Edmund Optics, 20[mm] X 37[mm], 50R/50T) and hits the galvanometer mirror (General scanning Inc., VM500) where it is then reflected down to the stage. This galvanometer mirror can rotate between -50 degree to +50 de-

gree. The AD/DA/DIO board (Interface company ltd, CBI360116) installed into the PC that controls the motor driver (MiniSAX) also controls laser position. It can work around a 400[mm] square stage. This board also controls the on/off interface of the laser using the TTL signal from the DIO.

The AD port of this board connects to the photo sensing circuit. We have developed a laser tracking system using this photo sensor (Hamamatsu Photonics K.K., G7189), a laser, and a half mirror. On the paper we have affixed retro-reflective material to serve as markers and copper foil as a heatsink. The photo sensor has been placed conjugate to the half mirror through which the laser passes through, making it possible for the photo sensor to then sense the laser output when it is reflected by retro-reflective material on the paper. This system can thus detect the position of the marker by checking the output from the photo sensing circuit.

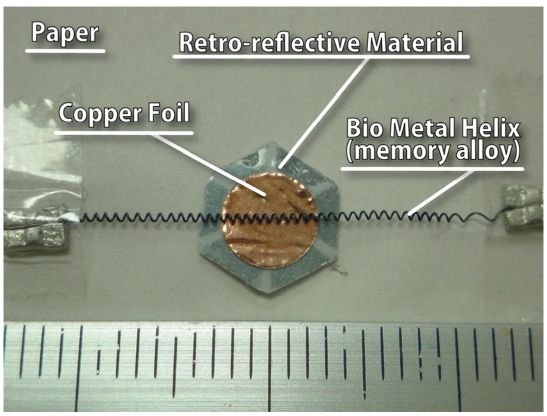

Figure 2 : Animated paper module

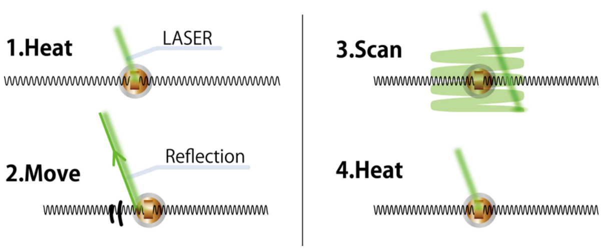

Figure 3 : Control method

The system can scan and track the positions of multiple markers and heat the points in the order indicated by the user. Using this system, it becomes easy to automatically and wirelessly transfer energy to isolated points, allowing for precise motion control.

Because of this structure, it bends about 60 degree. It depends on the flexibility of paper, retro-reflective and copper foil.

APPLICATION

Our SMA-enhanced paper platform can be used in conjunction with printed graphics, from multi-colored patterns to large-scale photos, to provide augmented paper experiences.

To exhibit this system, we have developed a special box with a protective laser filter that would allow anyone to safely animate their paper creations using a laser.

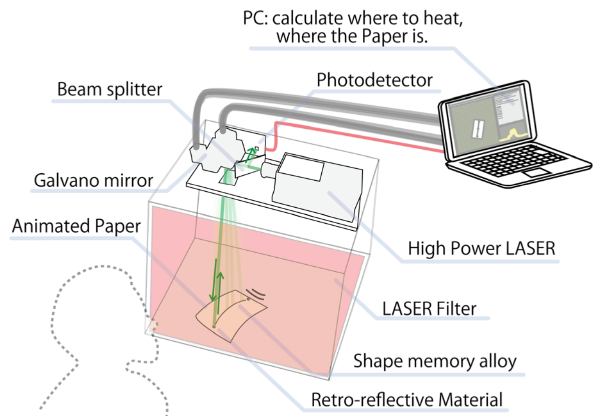

Figure 4 : Laser system

PRACTICALITY & SAFETY

To make this system accessible to anyone interested in interactive crafts and rapid prototyping, it is possible to create a more cost-effective version of this system using components from cheaper and more readily available consumer products such as the lasers found in Blue-Ray drives or the micro-laser scanners used in projectors because the wattage in these lasers is adequate for actuation. Safety is also something we have carefully considered throughout our research. Our method will not cause fires because SMA shrinks at approximately 100 degrees Celsius while paper burns between 250 - 450 degrees Celsius. Moreover, rather than heating the paper directly, our laser system heats the copper foil, which serves as an absorptive material.

CONCLUSION & FUTURE WORK

Our goal is to create a new platform that can be easily understood and manipulated in order to help people regain their willingness and excitement in creating things with their own hands.

REFERENCE

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