A Dynamic AR Marker for a Paper Based Temperature Sensor

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Abstract. This paper presents a proof of concept technology for a novel concept of dynamic markers for Augmented Reality. Here, by dynamic we mean markers that can change on external stimuli. Thus, the paper describes the use of ambient dynamic Augmented Reality Markers as temperature sensors. To achieve this technology we print patterns on an AR marker using thermochromic inks of various actuation temperatures. Thus, as the temperature gradually changes, the marker morphs into new marker for each temperature range. Thus here we present our preliminary results for three temperature ranges and discuss this work can be extended and applied in the future.

Keywords: thermochromic, sensor, temperature, paper based, paper.

1 Introduction

Augmented Reality (AR), 2D Barcode, etc are becoming powerful technologies that surround us in the world today. Many such technologies are used in various fields to present more information, enhance interactivity, experience, etc. One common feature that most such technologies have is the use of a marker/tag which is recognized through the use of a camera. Technologies for such recognition and processing of these markers have become more and more powerful and even moving onto mobile devices such as smartphones [4]. As these devices get smaller but more powerful, users today are able to install these complex programs and carry them around making the Augmented Reality technologies move towards ubiquity [3].

Using this move as an advantage, this paper focuses on a new type of markers for AR technologies. One main characteristic of Augmented Reality markers are that they are static. Thus, this work tries to address this characteristic by introducing another dynamic characteristic to the marker. We use thermochromic inks to achieve this dynamic characteristic. Thermochromic inks are inks that become colorless when you heat them beyond their actuation temperature and reappear when it cools below this actuation temperature. Thus, by printing

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squares of different actuation temperature themrochromic inks, we intend to explore the dyanamicity of this marker.

As a proof of concept, this paper presents the initial work, the development of a paper based temperature sensor using dynamic AR markers. For situations where a device temperature needs to be measured through a computer, we envision an application where we use this dynamic marker as a temperature sensor. Thus, in most cases, this method will replace complex temperature sensing circuitry with a simple paper based sensor and a camera. In addition, it could also be a simple piece of paper that you could carry in your wallet or bag as a mobile temperature sensor by simply reading it with your smart phone.

One of the closely related works to this work is the use of thermal markers used in a medical related application [2]. This work uses the difference between the body temperature and reflective marker read by a thermal camera to identify persons. However, in this paper we focus more on the change of the marker due to the temperature. Thus we present this paper based temperature sensor.

2 Method

As our initial prototype, we printed a modified ARToolkit [1] marker as a temperature sensor as in Figure 1(a). In this case, as shown in the example Figures 1, inks with different actuation temperatures are printed in the form of a AR marker with each pixel being a different temperature inks (or groups of pixels strategically placed being same ink). As the temperature increases each pixel would become colorless as seen in Figures 1(b),(c),(d). With more pixels with different actuation temperatures, we could achieve a higher resolution for the temperature.

Once this tag is placed on the device we require to measure the temperature, the relevant pixels will disappear and the tag will reveal the current temperature of the device. Then a simple web camera with an AR application could read the temperature off the AR maker.

For this initial version, in addition to a simple OpenCV AR algorithm for the marker detection, we implemented a basic AR application for the temperature

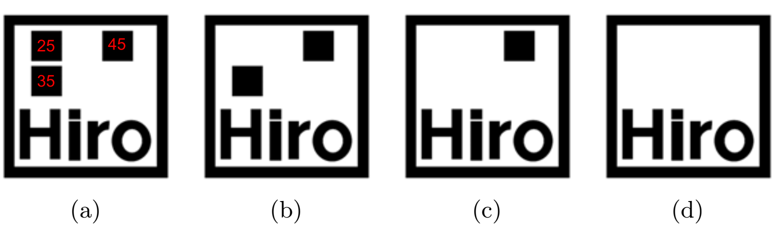

Fig. 1. Example AR marker for temperature sensing (Red marking are the actuation temperatures of each pixel and would not appear in the marker) (a) Marker at temperatures below 25^0C, (b)Marker at temperatures between 25^0C and 35^0C, (C)Marker at temperatures between 35^0C and 45^0C, (d) Marker at temperatures above 45^0C

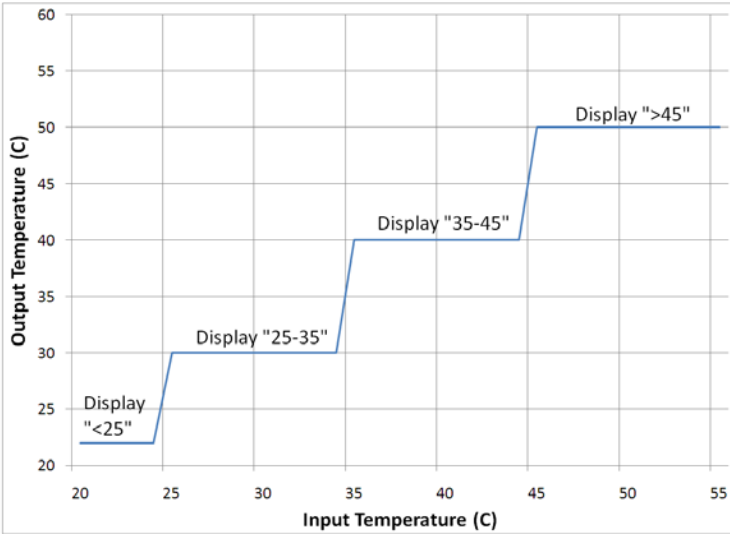

Fig. 2. Measuring and displaying the temperatures

detection. Thus upon detection of the marker, the application displays the range of the temperature on to the display (Figure 2).

3 Results

Example application is as in Figure 3 and Figure 4. Here, we attached the marker to a 3D printer during its idle time. Currently the detection shows the temperature to be between 35^0C to 45^0C (Actual temperature was 37^0C). In the second application we attached the marker to a server machine which displays the temperature as 20^0C to 35^0C. These readings can be improved further by adding more pixels with thermochromic inks of different actuation temperature.

Fig. 3. Measuring the temperature of a 3D printer

Fig. 4. Measuring the temperature of a server

As the results indicate, as the inks have a gradual change over about 2^0C, the reading is not accurate during the margins of the ink actuation temperatures. However, as mentioned before the use of inks with customized actuation temperatures would increase this accuracy.

4 Discussion

As observed, this temperature sensor gives fairly easy reading of the temperature. However, the current implementation is limited in its range and resolution due to the use of off the shelf thermochromic inks. The actuation temperature of thermochromic inks are customizable. Hence, based on the application, this temperature sensor can be extended in its range and resolution to get a more accurate temperature reading. Thus, this marker has the potential to be applied anywhere in a very ambient manner.

However, there are some key limitations to this technology. First is, as this technology uses, AR methods, lighting, and clear vision should be available for proper reading of the marker. In addition, in some occasions, if the temperature is such that, some of the pixels are only slightly actuated, it may result in incorrect readings. For this purpose, the actuation temperatures must be fine tuned.

4.1 Potential Applications

The simplicity and the ease of use this temperature sensor holds a key possibility to apply this technology to many fields of application. One of the earliest possible uses is the personal uses, where as mentioned earlier, the users can carry this temperature sensor in their wallets or bags just as a piece of paper. Thus upon requirement the temperature can be easily read using a smart phone instantly.

In addition, similar to QR codes on various products, the marker can be also integrated on to temperature sensitive products. Thus by simply placing the marker on the product, the users can read the temperature of the marker. To increase the robustness of this application on products, we are exploring the use of QR codes instead of AR markers for this purpose. In addition, this would help the use of widely available third party applications to read the dynamic QR codes.

The ability to use this temperature sensor as an inexpensive 'wireless' sensor could be useful in various industrial applications. In particular cases where the use of isolation chambers, etc. are required, such a sensor can easily replace messy or expensive wiring and temperature sensing equipment to simply use this sensor with a web-camera. Thus in similar applications, this type of paper based sensor could be useful as an inexpensive and simpler alternative.

5 Future Works

This is our initial work into the exploration of dynamic markers for Augmented Reality. As a proof of concept this paper presents some initial results of the development of a paper based temperature sensor.

As one of the major areas we are researching with this technology is dynamically 'actuating' this marker. I.e., we are exploring the possibility to change the marker based on various external stimuli. For this purpose, we are investigating the use of peltier elements as the thermal actuator. Peltier elements have the capability to heat and cool its surface just by reversing the supply voltage polarity. Thus once attached to the marker in a pixelated format, they can dynamically heat and cool different pixels, allowing the marker to morph into another marker. Hence, this would radically open up a new area of AR marker technology, adding a time variance dimension.

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