Easy3D: A Holographic Advertising Platform

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Outline

1. Introduction
2. System Architecture
3. Experiment Results
4. Conclusions

Introduction

- Hologram has seen tremendous progress in recent times.
- With holographic display's capabilities of fully three-dimensional (3D) image reconstruction, nowadays there is an increasing number of holographic displays installed on popular consumer electronics, e.g., interactive Hello Barbie Hologram.

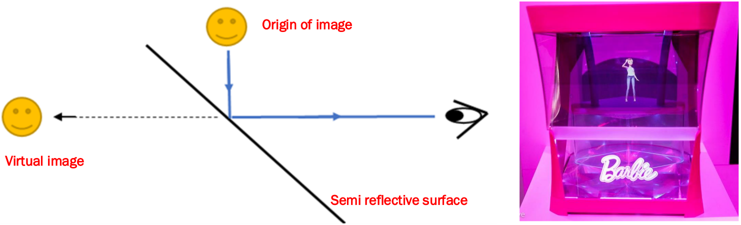

Photo Credit : Kris Naudus (AOL/Engadget)

(a) (b)

Figure 1: (a) Holographic principle (b) Hello Barbie Hologram

- However, little attention has been paid to the advertising market driven by restaurant industry.
- With the use of holographic displays on advertising context such as the restaurant menu, consumers are able to view a stereoscopic 3D food before deciding what to eat.

Photo Credit : Japan Airlines

Figure 2: Model food dishes in a restaurant in Japan.

- We propose a holographic advertising platform, namely Easy3D, to better represent a three-dimensional food for capturing the attention of passersby at restaurants.

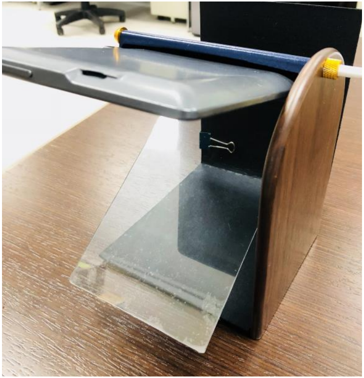

Figure 3: Easy3D: A Holographic Advertising Platform

Hardware designs

- Easy3D is equipped with a tablet computer and transparent plastic board.

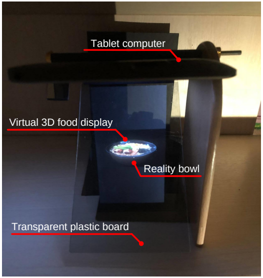

Figure 4: Configuration of instrumentations embedded on the Easy3D.

System Architecture

Software designs

- The most natural way to do this is to interact with the Easy3D by gesturing.
- The gesture-based navigation is devised into the Easy3D in order to invoke a context menu by performing the gesture.

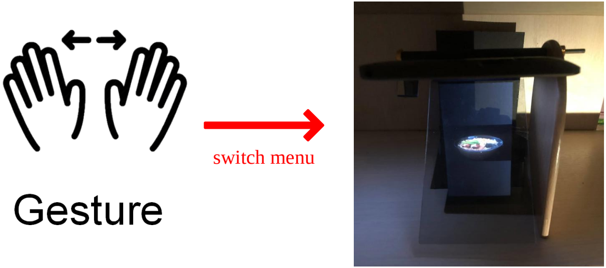

Figure 5: Wave hands to swtich the menu.

- For each pixel of tth incoming frame I_t^{YUV} in YUV color space obtained from front camera of tablet computer, we first detect the human skin color based on the value mapping between YUV to YCbCr color spaces as follows:

$$d_t = \begin{cases} 1, & T_u^{C_r} > I_t^{C_r} > T_l^{C_r} \wedge T_u^{C_b} > I_t^{C_b} > T_l^{C_b} \\ 0, & \text{otherwise} \end{cases}, \quad (1)$$

where

  - $I_t^{C_r}$ and $I_t^{C_b}$ denote the Cr and Cb pixel values mapped by I_t^V and I_t^U in YUV color space, respectively;
  - $T_u^{C_r}$, $T_l^{C_r}$, $T_u^{C_b}$ and $T_l^{C_b}$ are the upper and lower bounds in the YCbCr color space and can be set to 177, 137, 127, 77, respectively.
  - Note that d_t denotes the binary mask that labels with '1' meaning that the pixel is part of human skins; otherwise, it is part of background and labeled with '0'.

System Architecture

(a) (b)

Figure 6: Results of motion field detection: (a) original frame; (b) detected binary mask d_t.

- To determine the moving trajectories generated by consumers' sliding their hand in front of the Easy3D, the motion field d_f is then extracted from either pervious mask d_{t-1} or first mask d_0 to avoid a gradual sliding as follows:

$$d_f = \begin{cases} d_t \circ d_{t-1}, & |d_t \circ d_{t-1}| > |d_t \circ d_0| \\ d_t \circ d_0 \quad , & \text{otherwise} \end{cases}, \qquad (2)$$

where

  - $\circ$ denotes the exclusive OR computation, and $|d_t \circ d_{t-1}|$ and $|d_t \circ d_0|$ represent the numbers of pixels labeled with '1' in the masks $d_t \circ d_{t-1}$ and $d_t \circ d_0$, respectively.

- Next, the motion field is refined and denoted as d_r by using the morphological image processing to eliminate the sensor noise or block artifacts as follows:

$$d_r = (d_f \ominus N_8) \oplus N_8 \ , \tag{3}$$

where

- $\ominus$ and $\oplus$ denote the erosion and dilation processing, and N_8 denotes the 8-connected boundary.

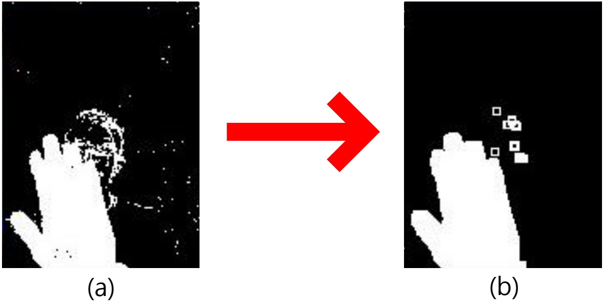

Figure 7: Results of motion field detection: (a) detected binary mask d_t; (b) refined motion field d_r.

System Architecture

- Additionally, we have a prior that gestures should be contiguous pieces with relatively large size, as demonstrated by the blue elements in figure below.
- Therefore, we employ the boundary tracing technique to further eliminate the outliers of small size, as indicated by the green and gray elements in figure below.

0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0
0	0	1	1	1	1	0	0	0
0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0

Figure 8: Snapshot of refined motion field. The yellow elements represent the image boundary and can be set to 0 for initialization. After the use of boundary tracing technique, the green and gray elements that represent the contiguous pieces with relatively small size are eliminated. Otherwise, the remained blue elements represent the gesture motion for current frame.

System Architecture

Figure 9: Results of motion field detection: (a) refined motion field d_r; (b) refined motion field d_r after performing boundary tracing technique.

- The gesture can be observed clearly after eliminating the outliers of small size from the refined motion field d_r, as demonstrated in figure below.

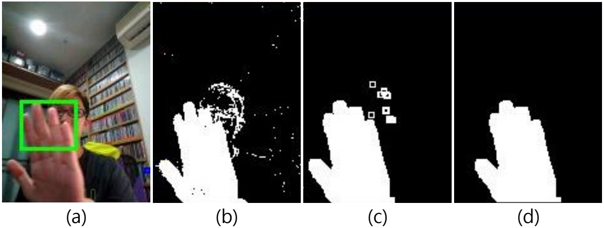

Figure 10: Results of motion field detection: (a) original frame; (b) detected binary mask d_t; (c) refined motion field d_r; (d) refined motion field d_r after performing boundary tracing technique.

- Finally, the moving trajectories are determined by comparing the current mask d_r with the first mask d_0 to discriminate three devised gestures, as shown in figure below.
- To train the DedistractedNet, the loss function is computed by using the cross-entropy as the category loss.

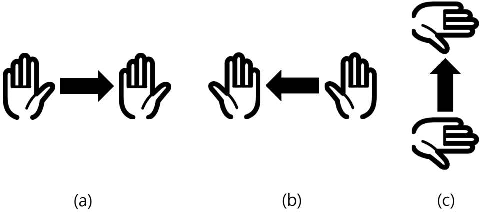

Figure 11: Demonstration of three predefined gestures for Easy3D. (a) Gesture 1: sliding hand from left to right position. (b) Gesture 2: sliding hand from right to left position. (c) Gesture 3: sliding hand from bottom to top position.

Experimental setup and dataset Qualitative results

- Easy3D possesses remarkable improvement on visual aesthetics.
- Easy3D simulates the foods of our physical reality to have a better guide than those of conventional hard restaurant menu.

(a) (b) (c)

Figure 12: Results of displaying stereoscopic 3D food on Easy3D: (a) reconstructed Ramen image; (b) reconstructed Unadon image; (c) reconstructed creamy corn soup image.

Quantitative results

- Easy3D can successfully recognize the gesture under simple and complex backgrounds.
- Table reports the accuracy of gesture recognition of Easy3D in such two backgrounds over 50 times, respectively.

Table 1: Accuracy of gesture recognition in simple and complex backgrounds

Scenarios	Gesture 1	Gesture 2	Gesture 3
Simple background	96%	98%	92%
Complex background	92%	94%	90%

Video demonstration

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Conclusions

- In this study, we have proposed a novel holographic advertising platform named Easy3D to capture the attention of passersby at restaurants by representing a stereoscopic 3D food.
  - A consumer can easily browse interactive and stereoscopic 3D menu by performing the gesture that significantly facilitates customer's perception of restaurant experience, as demonstrated in our experiment results.
  - Easy3D is capable of obtaining a satisfactory result (with accuracy values of 90%-98%) in either simple or complex backgrounds.

Thank you for your attention.