Painted Face Effect Removal

By A Projector-Camera System With Dynamic Ambient Light Adaptability

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Motivation

While projectors are widely used in classroom and conference room for representation, the embarrassing and annoying phenomenon called painted face effect occurs when the presenter stands in front of the screen.

Fig.1 Painted face effect

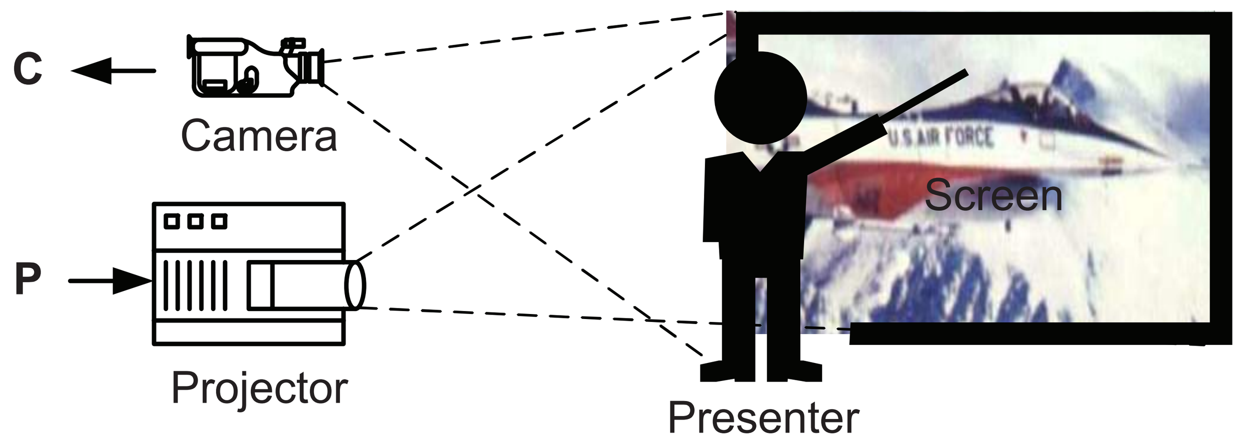


Fig.2 Illustration of a projector-camera system
***P**: image to be projected / **C**: image captured*

Introduction

We aim to remove painted face effect based on a projector-camera systems as shown in Fig.2. By telling the location of the presenter, the projector contents can be adaptively modified according to the foreground mask. However, since the lighting condition may be changed by time, a dynamic ambient light adaptation scheme is also proposed.

Algorithm

Our system adaptively modify the projector image **P** according to the camera image **C**. If there is no presenter standing between the projector-camera system and the screen, the relationship between **P** and **C** is formulated as $\mathbf{C} = T(H(\mathbf{P}))$,where *H(.)* stands for a geometry transform and *T(.)* stands for a photometric transform.

We proposed a new nonlinear photometric model, which can reach higher precision requirement and keep the computational overhead low at the same time.

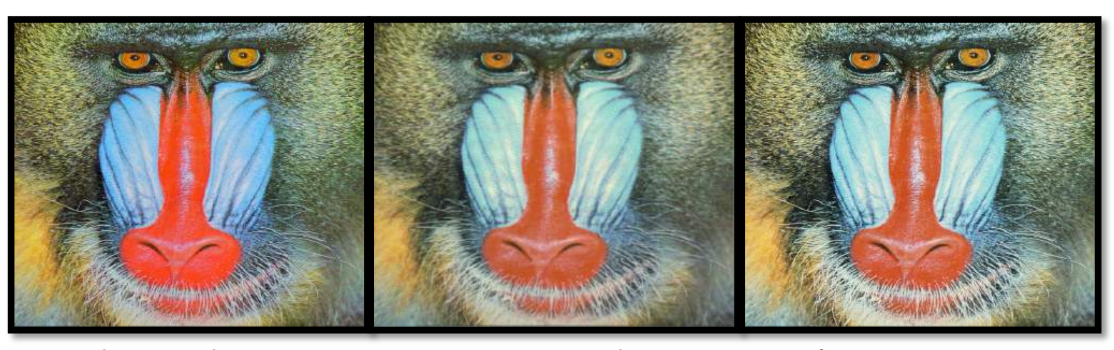
$$\hat{\mathbf{C}}_{(x,y,t)} = \mathbf{F}_{(x,y)} + \mathbf{V}_{(x,y)}\mathbf{P}_{(x,y,t)} + \hat{\mathbf{F}}_{(t)}$$

$$\mathbf{V} = \begin{bmatrix} V_{R,1} & V_{R,2} & \cdots & V_{R,18} \\ V_{G,1} & V_{G,2} & \cdots & V_{G,18} \\ V_{B,1} & V_{B,2} & \cdots & V_{B,18} \end{bmatrix} \qquad \mathbf{P} = \begin{bmatrix} \mathbf{P}_{cubic} \\ \mathbf{P}_{quadratic} \\ \mathbf{P}_{linear} \end{bmatrix}$$

$$\mathbf{P}_{cubic} = [\; P_R^3 \quad P_G^3 \quad P_B^3 \quad P_R^2 P_G \quad P_R P_G^2 \quad P_G^2 P_B \quad P_G P_B^2 \quad P_B^2 P_R \quad P_B P_R^2 \;]^T$$

$$\mathbf{P}_{quadratic} = [\; P_R \quad P_G^2 \quad P_G^2 \quad P_R P_G \quad P_G P_B \quad P_B P_R \;]^T \qquad \mathbf{P}_{linear} = [\; P_R \quad P_G \quad P_B \;]^T$$

where P is computed from projector image, and V is color mixing matrix obtained by solving an over-determined system with N^3 color samples, often N=4 leads to a satisfied result.



Projector image   Warp camera image   Synthetic camera image

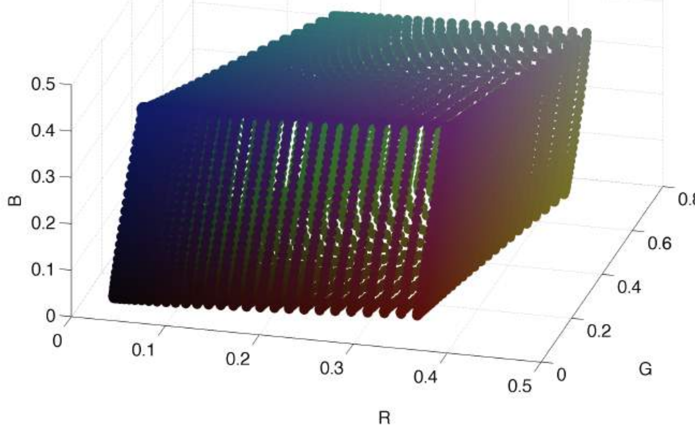


Fig.3 Synthesis result of Mandrill.   *Fig.4 An RGB cube*

Fig3 shows that the proposed cubic model is quite close to the camera image
Fig4 shows the photometric transformation of full RGB space

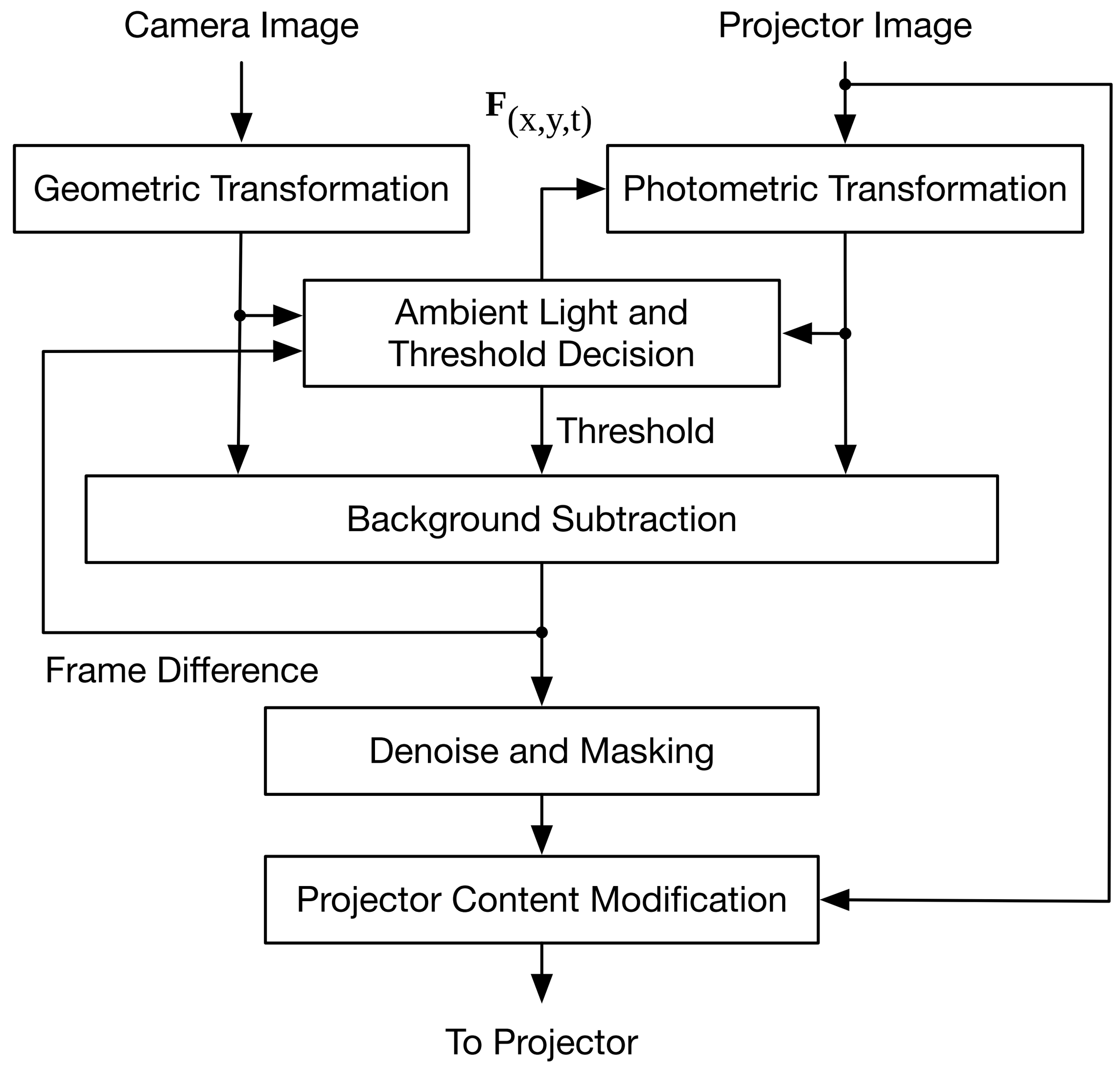
F and $\hat{\mathbf{F}}$ are ambient light terms at initial and the global dynamic correcting term at time t.

$$\hat{F}^*_{(t)} = \underset{f^*_{(t)}}{\operatorname{argmin}} \sum [C^*_{(x,y,t)} - (\hat{C}^*_{(x,y,0)} + f^*_{(t)})] \times \delta(P^*_{(x,y,t)} - P^*_{(x,y,t-1)}) \qquad * \equiv RGBchannel$$

The foreground object segmentation technique can be employed to locate the presenter. The frame difference mask can simply be obtained by the frame difference and a threshold. Frame difference is the distance between the camera image and synthetic camera image, which is generated as the background information. Threshold value is obtained based on Gaussian distribution of frame difference.

Proposed System

The proposed system has the following structure as well as an initialization step:



Result

Fig 5 shows the result of our experiment. The left most column is the captured images without painted face effect removal, the middle column captured images with painted face effect removal. Object masks, and the modified projector images $\tilde{\mathbf{P}}$ are demonstrated in the right most column. A case that the color of the presenter's cloth is similar to the projector image is also tested in Fig.6. It shows that under dynamic ambient light condition, the object can be correctly detected and the threshold can be decided effectively so that the painted face effect can be successfully removed without any artifacts.

Fig.5 Results under dynamic lighting conditions

Fig.6 Results under dynamic lighting conditions