Dynamic Luminance Correction for Colored Surfaces

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Figure 1: *Luminance correction for dynamic change of luminance properties with a people cut across in front of the projected wall. The correction was dynamically applied according to his movement, and finally in the right edge image, he stopped and completely disappeared.*

1 Introduction

Recently, large surrounding displays are widely used for providing immersive virtual environments. Latest trends of the projection system are using our accessible rooms as a surrounding screen, because the traditional special display like a CAVE is quite large and difficult for its maintenance. Therefore, precise correction techniques for projecting images on the walls surrounding us in our daily life are strongly required. Many geometrical and luminance correction techniques were proposed for improving the quality of projected images on the walls. However, those methods have to previously measure the 3-D shapes and reflecting properties of the target walls precisely. And also, simple assumption leads to the degradation of correction quality[Fujii et al. 2005]. This complex limitation is the bottle neck of the widespread use of the immersive projection techniques using the walls.

In our approach, we propose a dynamic luminance correction technique for projecting precise images on arbitrary-colored walls. This method requires no previous measurement, and within an only frame of projected images, adapts to the dynamic change of scene's reflectance properties, like moving curtains and peoples cut across in front of the walls.

2 Our Approach

Our proposal uses only a projector and a CCD camera. In our basic strategy, we estimate the response function of the projector at a point as a reference, and also, we get the luminance-ratio (L_{map}) of each pixel toward the reference point. The basic shape of the response function(F_{resp}) is unique for the projector, and the difference at each pixel is represented with the luminance ratio[Majumder and Gopi 2005]. Thus, the luminance projected at this coordinate (s, t) for input $i(r, g, b)$ is given by Equation1.

$$Luminance(s, t, i(r, g, b)) = F_{resp}(i(r, g, b)) \times L_{map}(s, t) \quad (1)$$

In this approach, we estimate these two factors (F_{resp} & L_{map}) in each projected frames.

At the first frame projection, we project a completely white image to the target walls, and obtain the reflected luminance information with the RAW image output of the camera. Although, at this point, we do not have enough information to estimate the response function, we only obtain the luminance-ratio (L_{map}) toward the reference point.

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At the second frame projection, we project the input image without any correction, and obtain the reflected luminance information with the same process. Although this reflected luminance is quite important for estimating the response function, there is a lack of response pairs for estimating that functions at each pixel. So in our approach, by using the luminance-ratio map obtained at the first frame projection, measured luminance at each pixel is normalized so as to be observed at the reference point. And then, at the reference point, we can get enough response pairs for estimating the response function (F_{resp}). Based on the assumption of the function's formula as an exponent function, that estimation is performed with the least-square method.

After the third frame projection, we can apply this response function at the reference point for other pixels by scaling with the luminance-ratio map, because the shape of the response function is basically same at every pixel. That is to say, we can achieve proper luminance correction for following frames. In addition, environment condition may have sudden changes of reflectance properties, with an exception of the constant shape of the response function. So we compare the predicted luminance with the estimated response function and observed luminance, and based on that difference, we update the luminance-ratio map in order to represent the change of the reflectance properties. Then, our approach can adapt to the dynamic change of the environment condition.

Figure1 shows our luminance correction results for dynamic change of the reflectance properties with a people cut across a projected surface. The clothes of the people include some variety of the reflectance properties, and it dynamically moves unpredictably. In such situation, our techniques can correct the images immediately, and the person himself is soon disappeared, without any prior measurements. The CCD camera's spec is 640x480 pixels and 200 fps. Although the camera is fully high-speed, actual capture speed is about 33 fps because of the exposure time of the camera and the response delay of the LCD projector. The estimation of the response function is processed with a GPU (GeForce GTX 295), and it can achieve totally 20 fps. (Supported by SCOPE, MIC, Japan)

References

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