# 야간 조명 아래 스테레오 비전의 반사 제거

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# Reflection Removal in Stereo Vision Under Night Illumination

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**Abstract**

Reflection considered as the view disturbing noise in optical systems, such as stereo camera in autonomous vehicles especially in night. Reflection caused by the street light or due to rainwater under adverse weather conditions. A blur image detected by the camera that results in wrong guidance to vehicle for detecting its track. A vehicle guidance approach through stereo vision can be same in day and night time. However it cannot be guided with same image analysis due to diverse illumination conditions. We develop the technique that shows its efficacy with illustrations of reflection removal off the camera lens and vehicle tracking control.

## 1. Introduction

Exclusion of reflection is imperative for clear vision in night. Reflection can be encountered usually in night due to street lights or rain water under adverse weather conditions. Autonomous vehicles with stereo camera suffer this situation as vehicle could not justify the clear track when reflection occurs.

Existing vision system are not able to provide the clear information of particular image taken by cameras in autonomous vehicles. However, clear vision should be a high requirement and must be controlled under different environment, weather and light conditions; such as the street light reflections occur on the track.

The approach we, propose defines how reflection gets eliminated from the stereo vision yielding the stable and clear image. Our approach comprise image processing technique. As the real and virtual (or reflected) image may appear at different distances from the camera this may confuse the auto-focusing device. In this paper we, present the image analysis for night image sequences, suitably matching the different perceivable objects under night illumination.

## 2. Related Works

Several works on image analysis proposed in recent studies; however they mainly rely on motion and focus and assume that the virtual image overlap the real image like mix images, which makes them quiet feasible in our case. These analysis can be done through blind image separation, independent component analysis and kernel independent components analysis.

Mohammad Reza Alsharif et al. has presented the approach using blind image separation (BIS) technique to recover multiple original sources from their mixtures [1]. A second order statistics approach has been deployed on this technique to remove reflection from the window glass images. The reflection image and the image behind the glass are considered as blind sources. The proposed technique based on the assumption that sources are mutually un-correlated. If they are un-correlated, their sub-bands obtained by linear filters are un-correlated too. The main issue of this technique; that both the images are on the same view-angle as well as it concerned about the frequency of the image mixtures. However, this method is not useful for those images which are at distant from each other.

Hany Farid et al. had suggested to separate the incidental from intrinsic aspects as well as the lighting from the image and they approximate this combination as a linear mixing process [2]. They also considered the same illustration as discussed above. By using the statistical tool of independent component analysis (ICA) they assume that sources are independent from each other according to the assumption of independence the separation is possible. They transform the image through joint distribution into separable product of 1D

distribution by applying rotation and scaling to that distribution. They are concerned with the linear independent sources.
Masaki Yamazaki el al. 2006 rendered their idea for the removal of reflection through kernel independent components analysis (KICA) [3]. As KICA methods are effective for non-linearity.

## 3. Proposed Method

We propose an approach of using KICA technique. As the reflection dislocate the clear view off the stereo camera lens. This approach begins with the pair of images taken through the stereo camera at the same position. There is a single object but the pair of stereo cameras take this image as in pair from each lens. The reflected image is removed from the observed image by applying the analytic KICA.

### 3.1 KICA implementation

KICA is based on high order statistical moments. The observed images observed through stereo camera X = (x1, x2) its matrix form can be written as:

$$X = NS \quad (1)$$

The matrix N and matrix S are written as follows:

$$N = \begin{bmatrix} a1\ b1 \\ a2\ b2 \end{bmatrix}, \quad S = \begin{bmatrix} P \\ R \end{bmatrix} \quad (2)$$

Where P = (p1, p2) and R= (r1, r2) are the amount of light contributed by the scene and reflection. The observed image X is a linear sum of these images and coefficients (a1, a2) and (b1, b2) can be changed. The input images (x1, x2) would be solved through linear matrix equations after having simulated data [3]. Since image is nonlinear, we compute our analysis including the non linearities, we can rewrite Eq.(1) as:

$$X = f(NS) \quad (3)$$

where, $f$ is a non-linear function. Firstly the source signals $S$ are mixed by linear model of Eq (1), then a non-linear function $f$ applies and it is finally observed as $X$.
Assuming $X$=(x1,x2) is the matrix of samples, using the idea of ICA seeks to find a transformation matrix W, U = WX, to make the projection U high-order statistically independent [3]. KICA assigns the observed images from stereo camera into high dimensional implicit feature through nonlinear mapping and the observed image can be analyzed in feature space F.

$$\Phi : R^t \rightarrow F \quad x \rightarrow \Phi(x) \quad (4)$$

The data in the input space x1,x2 $\in R^t$ is mapped to potentially higher space feature F. Linear discriminant function in feature space F is a non-linear discriminant function in input space $R^t$ [3].

### 3.2 ICA Matlab toolbox:

ICA matlab toolbox is favorably works with our proposed technique.
It works on linearly mixed images. But in this case the required image is non-linear. In this toolbox, built-in algorithms are supplied with the default parameters and these default parameters already close to approximate optimum values for the typical data.
Moreover, we add KICA matlab program rendering to the proposed technique. KICA matlab program implements kernel method on ICA.

## 4. Experimental Results and Conclusion

First preprocessing is done by effective filtering of this image, then KICA algorithm is applied through the toolbox, initially main source was identified. Furthermore, relevant parameters of KICA get tuned according to image and intensity of identified main source. We achieve almost 85% reflection rectification.
The proposed idea facilitates the clear vision for perceivable object and track recognition. It would be feasible to separate the intrinsic aspect of an image from the reflected variations due to rain water etc. We have shown how the statistical tool of KICA can be useful in this regard. We can get rid of polarizer and anti-glare filters by applying this approach. Any navigational systems can be benefitted by this idea to get a clear and sharper image of targeted object or path.

## Reference

[1] Mohammad Reza Alsarif, Mahdi Khosravy and Katsumi Yamashita, “Window Image Reflection Removal by Blind Image Separation,”, Bulletin of Engineering, University of the Ryukyus, 2010
[2] Hany Farid and Edward H. Adelson. “Separating Reflection and Lighting using Independent Componenets Analysis,” IEEE Computer Society Conference on Computer Vision and Pattern Recognition, Vol. 1, pp. 262-267, 1999.
[3] Masaki Yamazaki, Yen-Wei Chen, and Gang Xu, ”Separation of Reflection Components by Kernel Independent Components Analysis,” International Jouranl of Computer Science and Network Security, Vol.6, No. 6, pp. 7-12, 2006.