TED UNIVERSITY

**CMPE 491_01: Graduation Project**

# Project Proposal

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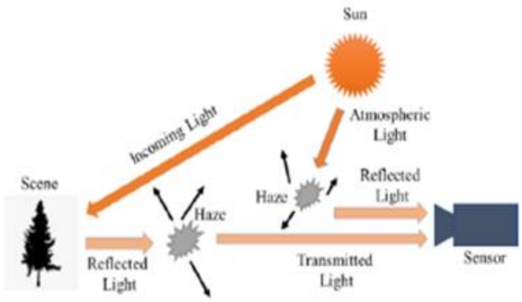
Effects such as fog, dust, smoke, haze, rain, snow, and low light that occur naturally or artificially in our environment limit the ability to see. These effects, which impair the ability to see, are significant problems that make life difficult for people. In order to act early and on time, it is necessary to recognize the external situation and the danger in the environment, if any. In a case where the view is partially or completely limited, the decrease in awareness creates problems in terms of security and perception. The attacks carried out by terrorists in the field of defense in foggy and rainy weather conditions are the most important examples of this problem. In addition, various problems and disruptions are experienced in transportation in bad weather conditions.

The issue of completely or partially removing effects on images obtained in fog and haze conditions is a subject that has been studied for many years and has rich literature. In defogging operation when the distance between the display device and the scene increases, the fog/haze thickness increases, and the transmission of the media decreases. Similarly, when the fog/haze density is high and varies locally, the complexity of the fog removal process increases. There are many waws to remove Fog and haze in photos. But generally, methods for fog and haze removal methods can be divided in to three categories as contrasted enhancement (Jia vd. 2020; Sammaraie 2015; Kim vd. 2011; Cai vd. 2011) restoration (Tan and Oakley 2001; Tang et al., 2014; Gibson et al., 2013; Fang et al., 2014; Galdran et al., 2015) and fusion-based (Son et al., 2015; Ancuti and Ancuti 2015; Guo et al., 2020; Zhang et al., 2014; Simeng and Qinghua 2021) .can be grouped into categories. Contrast enhancement approaches aim to improve the visual quality of hazy images to some extent; however, they cannot effectively remove the fog. Subcategories of image enhancement models, histogram enhancement that can be applied locally and/or globally (Simi et al., 2020; Joseph and Periyasamy, 2018; Joseph et al., 2017), frequency conversion methods: wavelet transform and homomorphic filtering, and Retinex method: single and multiscale Retinex (Hao et al. 2011). Restoration-based methods focus on recovering lost information by modeling the image degradation pattern and applying inverse filtering. The atmospheric light scattering model is one of the most widely used models in image fog removal, and the physical equivalent of this model is given in figure 1 below.




$$
\begin{aligned}
H(x,\lambda) &= T(x,\lambda) + AL(x,\lambda) && (1)\\
&= t(x,\lambda)RL(x,\lambda) + L_{\infty}\big(1 - t(x,\lambda)\big) && (2)\\
&= e^{-\alpha(\lambda)d(x)}RL(x,\lambda) + L_{\infty}\big(1 - e^{-\alpha(\lambda)d(x)}\big) && (3)
\end{aligned}
$$

Figure 1

The most important point in this model is the accurate estimation of the transmission rate and atmospheric light. The formula used in this case is at figure 1 (Cimtay, 2021).

In this formula, H(x, λ) represents the foggy/hazy picture, and T(x, λ) is the illumination value reflected from the scene and transmitted through the fog layer. AL(x, λ) represents air light reflected from the fog. The sensor collects the incoming lights, and the resulting image is the foggy/hazy image obtained. In Equation 2, t(x, λ) represents the transmission value from the fog, RL(x, λ) represents the light reflected from the scene and $L\infty$ represents the atmospheric light. The transmission component is calculated as e^(-α(λ)d(x)). Here d(x) is the scene depth map and α (λ) is the wavelength-dependent scattering term coefficient.

The Dark Channel Prior (DCP) Method (Kaiming et al. 2011) is one of the most widely used methods, using the dark channel per pixel. At the same time, quadtree decomposition was applied to measure atmospheric light. Another study based on DCP is (by Park et al. 2014). In this study, both pixel-based processing and similarity between spatial blocks were used to calculate the dark channel.

Recent approaches to defogging are mostly based on artificial intelligence approaches using deep learning models (Li et al., 2018; Li et al. 2018; Haouassi and Di, 2020). In (Cai et al. 2016), a deep architecture was developed using CNN, and a new unit called "bidirectional rectified linear unit" was added to the neural network. Better results were obtained in this study compared to previous studies. The work of (Rashid et al. 2019) used the end-to-end encoder-decoder CNN architecture to obtain fog-free images. In addition to the methods of defogging on a single image, methods that defog using video data are also used. For example, the study by (Ren et al. 2019) took advantage of the temporal similarity between consecutive video frames and trained the video data over CNN, assuming that atmospheric effects would be similar as a result of this similarity. In this way, it did the defogging process in the videos. In addition, in the study of (Dong et al., 2019), video defog was effectively performed by utilizing the Spatio-temporal similarity between video frames on the basis of DCP.

In addition to images taken in RGB band gaps, fog removal processes were applied to foggy images taken in Short Wave Infrared (SWIR) and Long Wave Infrared (LWIR) bands (argosfp7project, 2020). In these cameras, the bands that provide the best vision in the fog were selected and the improvement process was made. However, such cameras are quite expensive and difficult to manufacture (OEM cameras, 2021; FLIR-direct, 2021). Such camera prices are currently around $15,000. Therefore, this project, it is aimed to successfully remove fog, haze, dust, and smoke from traditional RGB images. Because both products will be low-cost and can be easily integrated into all systems running on RGB tape, which is currently used in transportation, security, first aid, monitoring, and surveillance.

In this study, artificial intelligence-based methods and especially the use of CapsuleNetworks and GraphNN structures, which have not yet been implemented in the literature, will be emphasized in order to improve foggy and hazy images. In this way, it is considered that much more successful fog and haze removal can be achieved, especially in situations where intense disruptive effects are dominant.

Website Link: https://fthygtl.github.io/new/