摘要

事件相机凭借其成像原理优势，在诸如高速、高动态范围等困难成像条件下取得了比传统图像更好的成像效果。但其也存在缺陷，例如现阶段的空间分辨率比较低、噪声水平比较高、不记录绝对光强值，等等。将事件信号和传统图像的优势结合，取长补短，实现超越二者能力范围的高质量成像，是事件相机与传统相机融合成像任务的目标。然而，尽管目前彩色传统数码相机已经普及，但当下常用的事件相机通常为单色相机，不记录颜色信息。受此影响，有关事件信号处理、事件视觉信号和传统图像融合成像算法的相关研究主要集中在单色事件信号的处理和利用上。

彩色数字图像一般以 RGB 三通道形式表示存储。为了采集 RGB 三通道彩色图像，绝大多数图像传感器都要借助复用的方法。当前通行的方式是一种空间复用的方法：对传感器进行空间划分，每部分空间采集不同颜色的光线信息，然后将各部分的信息进行算法整合，形成完整的三通道图像。也有利用时间复用方法的实践，一次拍摄一个颜色通道的图像，多次拍摄，最终形成场景的彩色图像。当前，市面上已经出现传感器上配备有拜耳滤光片阵列的彩色事件相机，但缺少能合理利用彩色事件的成像算法。此外，空间复用的成像方式导致的彩色事件信号空间细节缺失问题也不容忽视。因此，研究彩色事件信号的复用方法、处理算法，以及利用彩色事件信号与彩色传统视觉图像融合成像的方法，显得尤为重要。

本文研究彩色事件信号的复用方法与融合成像算法，完成了三项工作：时间复用的彩色事件信号成像数据集、空间复用的彩色事件信号恢复算法、彩色事件信号和传统图像的融合成像算法。本文的创新性与贡献点在于：

1. 为了获得真实捕获的彩色事件数据集，本文设计搭建了“显示器—滤光片—事件相机”成像系统，实现了马赛克事件和全尺寸彩色事件的同步记录，避免了信号的质量损失；
2. 为了实现空间复用的彩色事件信号的质量提升，本文设计神经网络模型，构建起“马赛克事件—全尺寸彩色事件”之间的映射关系，实现准确的彩色事件信号去马赛克处理；
3. 为了实现色彩保真的事件信号与传统图像融合成像，本文设计了基于彩色事件信号的图像去模糊模型。利用彩色事件信号包含的高时间精度信息，实现色彩保真的图像去模糊。

关键词：神经形态视觉，事件相机，去马赛克，融合成像

Multiplexing and Hybrid Imaging Algorithms of Color Neuromorphic Events

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ABSTRACT

Event cameras have achieved better imaging results than conventional cameras under many challenging imaging conditions such as high speed or high dynamic range due to their novel imaging principles. However, they are not without their limitations, such as relatively low spatial resolution, high noise levels, and the absence of absolute radiance values. Integrating the advantages of event signals and conventional images to compensate for each other's limitations and achieve high-quality imaging beyond the capabilities of either is the goal of hybrid imaging with event cameras and conventional cameras. However, despite the widespread use of color digital cameras, most event cameras are monochrome and do not record color information. As a result, current research on event signal processing, event visual signal analysis, and hybrid imaging algorithms with conventional images primarily focuses on the processing and utilization of monochrome event signals.

Color digital images are typically stored in the RGB format. To capture RGB color images, most image sensors employ multiplexing methods. The prevalent approach involves spatial multiplexing, where the sensor is divided into spatial regions, each collecting radiance information of different colors. These color information from different regions are then integrated using algorithms to form a complete three-channel image. Alternatively, some practices utilize temporal multiplexing, capturing images of each color channel sequentially through multiple shots to form a color image of the scene. Currently, there are color event cameras available in the market with Bayer filter arrays. However, the lack of imaging algorithms that can effectively utilize color events remains a challenge. Additionally, the spatial multiplexing imaging method leads to spatial detail loss in color event signals, which cannot be ignored. Therefore, research on methods for multiplexing color event signals, processing algorithms, and utilizing color event signals to hybrid with color conventional images for imaging is of paramount importance.

This paper focuses on the multiplexing methods and hybrid imaging algorithms of color event signals, and accomplishes three tasks: a dataset of color event signals for temporal multiplexing imaging, an algorithm for restoring color event signals with spatial multiplexing, and a hybrid imaging method for color event signals and conventional images. The innovations and contributions of this paper are as follows:

1. To obtain real captured color event datasets and avoid the gap between simulated output data and real data, this paper designs and constructs a "display-filter-event camera" imaging system, using temporal multiplexing to achieve synchronous recording of mosaic events and full-size color events, avoiding loss of signal in the spatial dimension;
2. To achieve quality improvement of color event signals with spatial multiplexing, this paper designs a neural network model to establish a mapping relationship between mosaic events and full-size color events, achieving accurate de-mosaicing processing of color event signals;
3. To achieve color-accurate hybrid imaging, this paper presents a color event-based image deblurring model. On the one hand, utilizing the high temporal accuracy information contained in color event signals to remove motion blur in color conventional images in fast-moving scenes; on the other hand, leveraging the low noise and full-size resolution characteristics of color conventional images to enhance the quality of color event signals.

KEYWORDS: Neuromorphic Vision, Event Camera, Demosaicing, Hybrid Imaging