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OpenCV colour detection and segmentation invisibility cloak

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Abstract

Have you ever considered the idea of making things appear invisible, similar to the concept of the invisibility cloak in Harry Potter. An invisible cloak, as popularized in fiction like Harry Potter, is a hypothetical concept where a garment or device renders the wearer invisible to the naked eye. In reality, such technology doesn't exist, and achieving invisibility involves complex scientific and optical challenges. While there have been advancements in camouflage and stealth technology, creating a true invisible cloak remains a subject of fascination and imagination in the realms of science fiction and fantasy. While we know there's no actual magic involved, achieving this effect in movies relies on graphic tricks. The concept of an invisibility cloak is a blend of science, fantasy, and human imagination. This project explores how to create your own "Invisibility Cloak" using Python and the OpenCV module, focusing on image processing and segmentation. It delves into manipulating objects of specific colours or textures using OpenCV. The process involves capturing and storing the background frame, identifying red, blue, and green-coloured fabric through algorithms, creating a mask to isolate the RGB-coloured fabric, and ultimately generating a magical augmented output to simulate an invisibility cloak.

Keywords: OpenCV; Colors detection; Invisibility clock; Python 3.4; Image Segmentation

1 Introduction

Invisibility refers to the state in which an object cannot be perceived visually. An object in this condition is termed invisible, signifying its lack of visual detectability. Although the term is commonly associated with fantasy and science fiction, where objects achieve imperceptibility through magical or technological means, its principles also find real-world applications, particularly in the realm of physics. The foundational concept of invisibility revolves around the idea that objects become visible when they interact with light within the visible spectrum. Visibility occurs when light from a source strikes an object's surface and is then detected by an observer's eye. The most straightforward form of invisibility, both in fiction and reality, involves an object that does not reflect light, allowing light to pass through it. In the natural world, this quality is known as transparency, exhibited by various materials, although no naturally occurring material is entirely transparent. In the realm of science fiction and advanced physics, the concept of a cloaking device, often termed an invisibility cloak, focuses on manipulating light waves. This manipulation aims to redirect light around an object, creating the illusion that the object is absent. It's important to note that an object's visibility may vary based on the observer's visual abilities or the instruments used for observation. Consequently, an object may be classified as "invisible to" a specific individual, creature, device, or entity. The evolution of Artificial Intelligence led to the emergence of Computer Vision in the late 1960s. This field aimed to enhance the cognitive capabilities of artificial systems by integrating cameras to interpret visual information, mirroring the human visual system. Consequently, Computer Vision

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sought to enable the recognition of real-world 3D objects from 2D images, each capturing a moment in time or ongoing events.

2 Related Work

Puneet, Vasudha Bahl et al.,[1] This document serves as a guide to crafting a personalized 'Invisibility Cloak,' walking through the process of creating a compelling illusion of invisibility within a frame using Python and the targeted features of the OpenCV module, specifically focusing on Image Processing and Image Segmentation. The exploration delves into the intriguing domain of manipulating objects based on their distinct colour or texture, harnessing the capabilities of the Python OpenCV library. The journey commences with capturing and preserving the background frame, followed by the utilization of specialized algorithms for identifying red-coloured fabric. Subsequent steps involve isolating the red fabric through the generation of a mask. The final revelation unveils the enchanting output that breathes life into the Invisibility Cloak.

The late 1960s marked the inception of computer vision, a field dedicated to imbuing artificial systems with the ability to comprehend the visual world akin to the human visual system. By outfitting machines with cameras, computer vision aimed to empower them to interpret 3D objects from 2D images, enabling them to perceive and understand the world as humans do. This document embarks on a journey to infuse a touch of magic into the real world, exploring the creation of an Invisibility Cloak through the perspectives of computer vision, image processing, and the capabilities of Python and OpenCV.

Xue-Feng Zhu, Juan Tu, Bin Liang et al.,[2] The enchanting concept of a magical cloak, reminiscent of Harry Potter's, has been a longstanding human aspiration. Recently, inspired by the emergence of metamaterials, transformation optics has opened up new possibilities for manipulating wave propagation, allowing for the creation of astonishing illusion effects. In this study, we introduce an innovative transformation recipe where the cloaking shell acts akin to a "cloaking lens," offering nearly all the desired features for a genuine magical cloak. One particularly exciting aspect of this approach is its ability to render an object with arbitrary characteristics, such as size, shape, or material properties, perfectly invisible using positive-index materials. This significantly advances the practical realization of a broadband cloaking device, achievable with existing materials. Additionally, individuals concealed within the hidden region can communicate seamlessly with the surrounding world, while the lens-like cloaking shell safeguards the cloaked source/sensor from detection by creating a virtual image. The manipulation of a continuously changing refractive index induces alterations in light propagation, resulting in illusion effects.

Traditional optical design, relying on homogeneous materials, primarily involves determining interfaces between two materials. The advent of artificial complex metamaterials has enabled novel wave manipulations that were previously unattainable with natural materials. Transformation optics, propelled by the progress in metamaterial implementation, establishes a link between coordinate transformations and material constitutive properties. This approach prompts researchers to reevaluate conventional optics foundations. Analogous to general relativity, the principle of transformation optics demonstrates that the field of waves (such as light, acoustic waves, and matter waves) can be controlled arbitrarily with specially designed structures. The ability to design and engineer the wave field provides researchers with exceptional flexibility to manipulate wave propagation, giving rise to extraordinary illusion effects, with invisibility cloaking standing out as a particularly popular and intriguing topic.

Neal N. Xiong, Yang Shen, et al.,[3] This paper emphasizes the significance of colour information in colour image segmentation and real-time colour sensing, impacting the outcomes of video image segmentation and accurate real-time temperature measurement. The document introduces a novel method for real-time colour image segmentation, leveraging colour similarity within the RGB colour space. The process begins by determining the dominant colour based on colour and luminance information in the RGB colour space. Subsequently, a calculation method for colour components is proposed to compute colour similarity, generating a colour-class map. This map is then utilized to classify pixels. Given the dynamic colour values of thermal inks that change with temperature variations, the segmentation results of thermal ink serve as a real-time colour sensor. The paper also suggests a method for colour correction and light source compensation to address potential inaccuracies in measurements. The discussion includes the application of the proposed segmentation method in conjunction with a colour sensor (thermal ink) for real-time colour image segmentation in Cyber-Physical Systems (CPS). This application is exemplified in fire detection, introducing a new method for identifying fire in videos based on these characteristics. Experimental results indicate the effectiveness of the proposed vision-based fire detection and identification method in videos, demonstrating accuracy suitable for real-time analysis.

Shervin emami1 et al.,[4] This highlights the increasing interest in computer vision over the last decade, driven by the consistent doubling rate of computing power every 13 months. Face detection and recognition, once considered esoteric, have evolved into popular areas of research within computer vision. They represent successful applications of image analysis and algorithm-based understanding, capitalizing on advancements in computing capabilities. The intrinsic nature of the problem makes computer vision not only a focus of computer science research but also a subject of neuroscientific and psychological studies. This interdisciplinary approach stems from the belief that progress in computer image processing and understanding can offer insights into the workings of our brains, and vice versa. Motivated by a general curiosity and fascination with the subject, the author proposes the development of an application enabling user access to a specific machine through in-depth analysis of facial features. The application will be crafted using Intel's open-source computer vision project, OpenCV, and Microsoft's .NET framework. This initiative aims to explore the intersection of computer vision, facial recognition, and user authentication, leveraging the capabilities of widely-used technologies.

Sapna Malik et al.,[5] In the realm of Harry Potter, the magical invisibility cloak captured imaginations, but in reality, no actual magic or invisible cloak exists; it's a product of cinematic graphic tricks. The concept of an invisibility cloak blends science, fantasy, and collective imagination. This paper guides individuals in creating their own 'Invisibility Cloak,' imparting a false sense of invisibility within a frame using Python and the OpenCV module, specifically focusing on Image Processing and Image Segmentation. The exploration involves manipulating objects of a specific colour or texture with the Python OpenCV library. The process begins by capturing and storing the background frame, followed by the identification of red-coloured fabric using specified algorithms. Subsequently, the red fabric is isolated by generating a mask, and finally, the augmented (magical) output is produced to simulate the effect of an Invisibility Cloak. These steps are detailed further in the paper, providing insights into the intricacies of creating the illusion of invisibility through image processing techniques.

Alessandro Massaro et al.,[6] This study presents our research on an image processing system specifically designed for the automatic identification of key features in electronic board welding's. Utilizing the widely-used ImageJ and OpenCV libraries, we have developed this system. Our emphasis on image segmentation employs the watershed technique, refining the system's capability to separate and distinguish objects within intricate electronic board welding images. We have meticulously crafted automated processes to streamline feature detection, minimizing the need for manual intervention. To assess the system's effectiveness, a series of tests were conducted to evaluate its ability to accurately extract features, optimize scale settings, and calibrate threshold values. The system demonstrates its proficiency by producing cropped images that highlight each identified defect. When integrated with post-processing 3D imaging, it becomes a valuable tool for efficiently managing production quality in electronic board manufacturing. In summary, our work revolves around the creation of a sophisticated image processing solution tailored for the automated detection and analysis of defects in electronic board welding's. This contribution aims to enhance quality control in the realm of electronics manufacturing.

Lahiru dinalankar et al.,[7] Identification of individuals through image-based methods has gained popularity in the mass media, although it is deemed less robust compared to fingerprint or retina scanning. This report outlines a mini-project focused on face detection and recognition conducted for the visual perception and autonomy module at Plymouth University. The technologies available in the Open-Computer-Vision (OpenCV) library and the methodology for their implementation using Python are discussed. For face detection, Haar-Cascades are employed, while face recognition utilizes Eigenfaces, Fisher faces, and Local Binary Pattern Histograms. The report details the methodology, including flow charts for each stage of the system. Results, presented through plots and screen-shots, are followed by a discussion of encountered challenges. The report concludes with the authors' opinions on the project and potential applications. This document serves as a report on the mini-project for Robotic Visual Perception and Autonomy, involving the construction of a system for face detection and recognition using various classifiers within the OpenCV library. Face recognition, being a non-invasive identification system, is highlighted for its efficiency in analysing multiple faces simultaneously. The distinction between face detection and identification is explained, and the project accomplishes both using different techniques, detailed within. The report begins with a brief history of face recognition, followed by explanations of algorithms such as HAAR-cascades, Eigenface, Fisher face, and Local Binary Pattern Histogram (LBPH). The methodology, results, challenges, and resolutions are then discussed, and the report concludes by weighing the pros and cons of each algorithm, along with potential implementations.

Mustafa Ali Mir et al.,[8] Over the past decade, there has been a notable surge in people's interest in computer vision, propelled by a steady increase in computing power every 13 months. Face detection and recognition, once considered esoteric concepts, have transformed into popular and successful applications of computer vision research and image analysis algorithms. In our study, we focus on detecting contours (shapes) of various geometrical figures in a given binary mask extracted from the HSV (Hue Saturation Value) range using Python 3.6, the Open-Source Computer Vision Library (OpenCV 3x), and NumPy. Our approach involves using fundamental functions for processing frames, including obtaining a live video feed, loading frames one by one, and detecting various shapes of red colours within the live feed frames. We then segment these shapes with a previously saved image at the exact location. The paper addresses three primary challenges in computer vision: finding contours, detecting specified colours, and segmenting with another image. State-of-the-art algorithms are applied to these tasks. HSV colour extraction is utilized to obtain the mask of the desired coloured object. To achieve high-quality image segmentation results, we employ Morphological operations, including Opening to remove unnecessary details, Erosion, Dilatation operations, and Gaussian Blurring to smooth the result. We integrate this contour detector with Convex Hull, which proves to be more effective than existing image segmentation algorithms in terms of both boundary and segmentation quality. Finally, we replace the pixel values of the red color region detected by the HSV mask with the pixel values of our background image, using bitwise operations to achieve the augmented result of an invisible cloak.

In [9] Identification of a person by looking at the image is really a topic of interest in this modern world. There are many different ways by which this can be achieved. This research work describes various technologies available in the open-computer-vision (OpenCV) library and methodology to implement them using Python. To detect the face Haar Cascade are used, and for the recognition of face eigenfaces, Fisher faces, and local binary pattern, histograms has been used. Also, the results shown are followed by a discussion of encountered challenges and also the solution of the challenges.

In [10] Managing student attendance in a large classroom poses challenges with traditional systems due to their time-consuming nature and susceptibility to errors during manual data entry. This paper suggests an automated attendance marking system employing face recognition techniques. The system utilizes Haar cascade for detecting facial features and the eigenface algorithm, implemented through Python programming and the OpenCV library. The proposed method incorporates Principal Component Analysis (PCA) to address issues like image lighting variations, camera noise, and diverse face orientations. Upon successful recognition of a student's face, the attendance record is automatically updated in an Excel sheet.

In [11] Have you ever thought of making visible things invisible, just like the Harry Potter? Have you ever thought how does one supersede backgrounds and add effects in a movie? The cloak was magical and invisible in Harry Potter, the movie. As we know there is no magic and no invisible cloak which exists in the world. It's all about the graphics tricks. The concept of an invisibility cloak is a mixture of science, fantasy, and the collective imagination. This paper helps to create one's own 'Invisibility Cloak'. It will make use of Python and OpenCV module specifically targeting Image Processing and Image Segmentation to create a false sense of invisibility in the frame. It will explore how an object of a specific colour or texture can be manipulated using the OpenCV library of python. To achieve this, initially we'll be capturing and storing the backdrop frame . Thereafter we'll be identifying the red coloured fabric by making use of the above mentioned algorithms. Then we'll segment out the red coloured fabric by generating a mask and then finally, we'll generate the final augmented(magical) output to create Invisibility cloak. These steps are discussed deeper in the paper.

In [12] Over the past decade, there has been a growing interest in computer vision, driven by the consistent increase in computing power every 13 months. Face detection and recognition, once considered esoteric concepts, have become popular applications of computer vision research and image analysis algorithms. This work focuses on detecting contours (shapes) of various geometrical figures within a provided binary mask extracted from the HSV (Hue Saturation Value) range. The implementation is carried out using Python 3.6, the Open-Source Computer Vision Library (OpenCV 3x), and NumPy. Fundamental functions are employed to process frames, involving tasks such as obtaining a live video feed, loading frames frame-by-frame, and detecting various shapes of red colours within the live feed frames. The identified shapes are then segmented based on a previously saved image with the exact location. This paper addresses three primary challenges in computer vision: finding contours, detecting specified colours, and segmenting images with another image. State-of-the-art algorithms are applied to tackle these tasks. HSV colour extraction is utilized to create a mask of the desired coloured object. To achieve high-quality image segmentation results, morphological operations such as Opening, which removes unnecessary details like white regions on the boundary of clothing, are applied. Additional operations include Erosion, Dilatation, and Gaussian Blurring to refine the mask and produce smoother results.

The contour detector is linked with Convex Hull, proving to be more effective than existing image segmentation algorithms in terms of both boundary and segmentation quality. The final step involves replacing pixel values of the red colour region detected by the HSV mask with the pixel values of a background image, achieved through bitwise operations. This process results in an augmented reality effect resembling an invisible cloak.

In [13] Invisibility cloaks, once confined to the realms of science fiction, are now becoming a tangible reality. Achieving truly effective cloaking technology necessitates an all-encompassing light-bending device. However, one straightforward method employed by scientists involves using cameras to record and project images from behind an object onto its surface, creating the illusion of invisibility. Companies like Hyper Stealth Biotechnology and The Quantum Stealth have made notable strides in invisibility technology. Quantum Stealth has ingeniously organized lenticular lens layers to generate "dead spots" behind the material at specific distances. When viewed from the front, the object concealed behind the cloth becomes invisible, revealing only the background. Consequently, the wearer appears to be invisible. Notably, the company's prototype material, as thin as paper, does not require a power source for its operation.

3 Model Architecture

The initial phase of implementing the Invisibility Cloak system through Color Detection and Segmentation with OpenCV involves image pre-processing. This step aims to eliminate noise and enhance image quality through the Morphological Transform Dilation process, as depicted in Fig 1. Subsequently, the image undergoes conversion from RGB to HSV, enabling the detection and segmentation of red/blue/green color objects. The resulting segmented image is then inverted and merged with the background. Following this, there is a conversion back from HSV to RGB, ultimately creating the Invisibility Cloak effect.

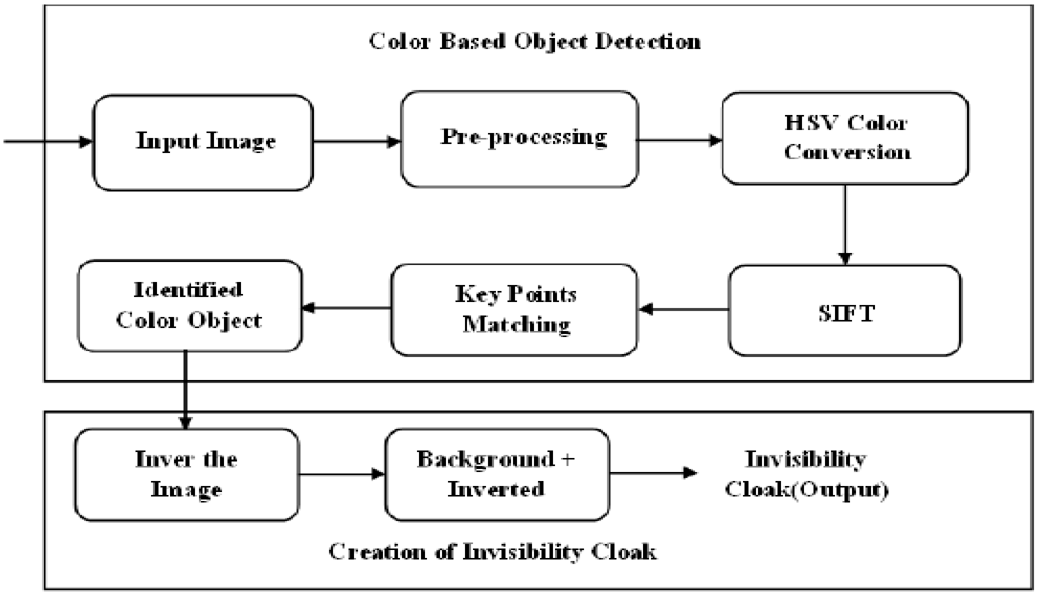

Figure 1 System Architecture of Invisibility Cloak

4 Mythology

The proposed system diagram for the partial implementation of the Invisibility Cloak using Colour Detection and Segmentation with OpenCV is represented in the above Fig 2

The image preprocessing technique is applied to a background image and a continuous stream of images. Subsequently, a feature extraction technique is employed. The image undergoes preprocessing for noise removal and RGB to HSV conversion. Extracted features are then stored in a database. The Morphological Transform Dilation process is implemented to eliminate noise from the images, enhancing image clarity and smoothing. The next step involves performing a bitwise AND operation between the image frame and a mask to specifically detect red/blue/green colors and discard others.

Following this, contours are created for each individual color, facilitating the segmentation of the red/blue/green-colored regions. The static background is displayed for the masked region, and the final output is generated and displayed.

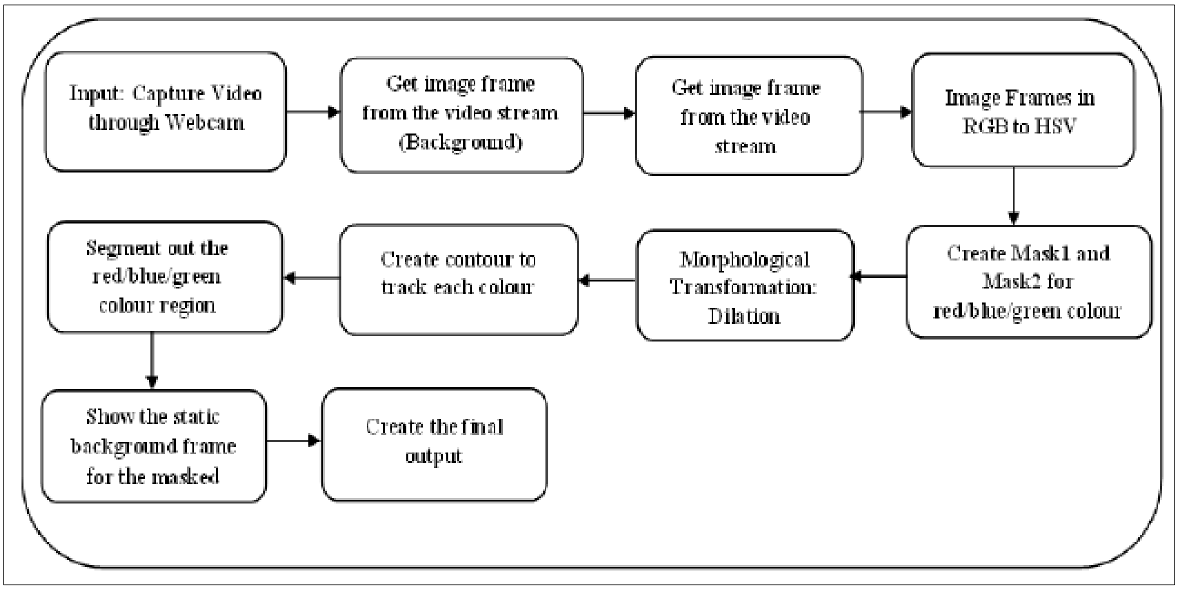

Figure 2 Flow of proposed system

4.1Design Methodology of Invisibility Cloak

The Design Methodology includes following steps as shown in the Fig 3. They are,
Step 1: Importing needed libraries and generate the output video.
Step 2: Recording and caching the background for each frame.
Step 3: Detecting the red/blue/green portion in each frame.
Step 4: Replacing the red /blue/green portion with a mask image in each frame.
Step 5: Producing the augmented output.

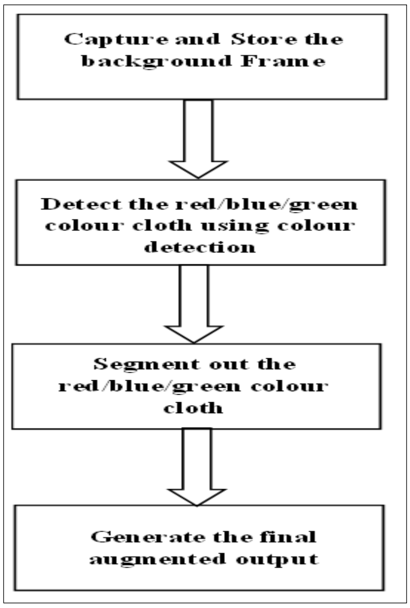

Figure 3 Design Methodology of Invisibility Cloak

4.2 Board Work of Invisibility Cloak

4.2.1 RGB Color Spacing

Colour spaces serve as mathematical representations for a collection of colours, and various colour models exist. Among them are RGB, CMYK, YIQ, HSV, and HLS. These colour spaces are closely tied to saturation and brightness. Devices like cameras and scanners can derive all of these colour spaces using RGB information.

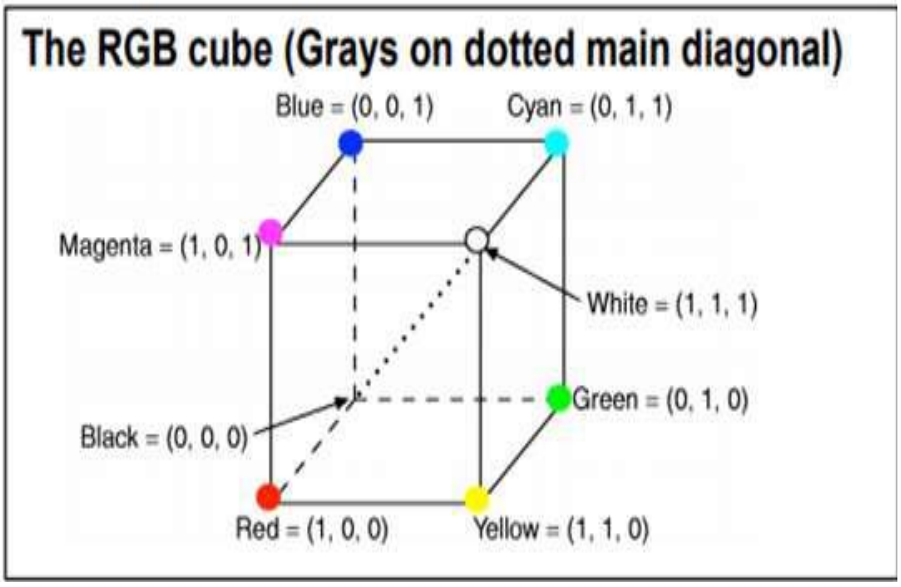

Figure 4 RGB Colour Spacing

The illustration in Fig 4 provides a detailed description of RGB Colour Spacing. RGB stands for Red, Green, and Blue, and it is extensively employed in computer graphics. These three primary colours, red, green, and blue, serve as the foundation for creating a multitude of colours. The RGB colour space can be visualized in a three-dimensional form, as depicted in the figure above.

4.2.2 Conversion of RGB to HSV

An RGB (coloured) image comprises three channels: Red, Blue, and Green. In OpenCV, the representation of a coloured image follows the [H, W, C] format, where H, W, and C denote image height, width, and the number of channels, respectively. Each channel in an RGB image has values ranging from 0 to 255.

Conversely, an HSV image also consists of three channels: Hue, Saturation, and Value. In OpenCV, the values for the Hue channel range from 0 to 179, while the Saturation and Value channels range from 0 to 255. To convert an RGB image to an HSV image in OpenCV, the cv2.cvtColor() function is utilized. This function facilitates the conversion of an image from one color space to another, as illustrated in Figure 5.

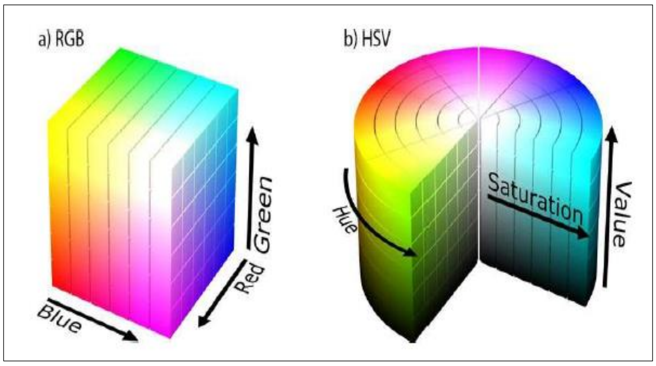

Figure 5 RGB Colour Spacing

4.2.3 Median Filtering

Noise removal is a crucial step in image processing, aiming to eliminate or minimize unwanted distortions in an image. Noise removal algorithms work by reducing or eliminating the visibility of noise through the smoothing of the entire image, with special attention to areas near contrast boundaries. In this context, we employ the Median Filter as a noise removal technique. The Median filter is a non-linear digital filtering method commonly used to mitigate noise in images or signals. It involves appending zeros at the edges and corners of the matrix, which represents the grayscale image. For each 3x3 matrix, the elements are arranged in ascending order, and the median/middle element of those 9 elements is determined.

Additionally, Basic Global Thresholding is employed as part of the noise removal process. In this method, if the value of A(i, j) is greater than or equal to the threshold T, it is retained. Otherwise, the value is replaced by 0. The threshold value, denoted as T, can be adjusted in the frontend to cater to the diverse requirements of different images. The determination of the threshold value is carried out using a trial-and-error approach.

4.3 Implementation

This chapter provides an in-depth description of the Invisibility Cloak implemented using Colour Detection and Segmentation with OpenCV. Its operation is contrary to the concept of green screening, where the background is removed; instead, this application focuses on removing the foreground. A cloak of red/blue/green-coloured fabric serves as the key element, although any colour can be employed with minor modifications to the code.

The logic is straightforward: each video frame is extracted using segmentation, enabling the separation of the background and foreground in the image. The foreground, based on a specific colour, is then substituted with the background, creating the illusion of invisibility. In this particular application, red/blue/green-coloured cloth is chosen for achieving the disappearing effect.

The workflow of this project involves the following steps:
1. Importing the necessary libraries and generating the output video.
2. Recording and caching the background for each frame.
3. Detecting the red/blue/green portion in each frame.
4. Replacing the red/blue/green portion with a mask image in each frame.
5. Producing the surprising output.

5 Results and Analysis

5.1 Snapshot of Background Image

Figure 6 Snapshot of Background Image

Upon initiating the invisibility cloak application, users are prompted to select a color from the dropdown list and activate the camera. Once the camera is initiated, the background image is captured at the count of 60, as depicted in Fig 6.

5.2 Snapshot of Background Image Capture Failed

Figure 7 Snapshot of Background Image capture failed

Upon launching the invisibility cloak application, users are required to choose a colour from the dropdown list and initiate the camera. Once the camera is activated, the background image is captured after a count of 60, as illustrated in Fig 7. However, in this scenario, the image capture is impeded by dim lighting conditions, rendering the camera unable to capture an image.

5.3 Snapshot of Invisibility Cloak for red colour

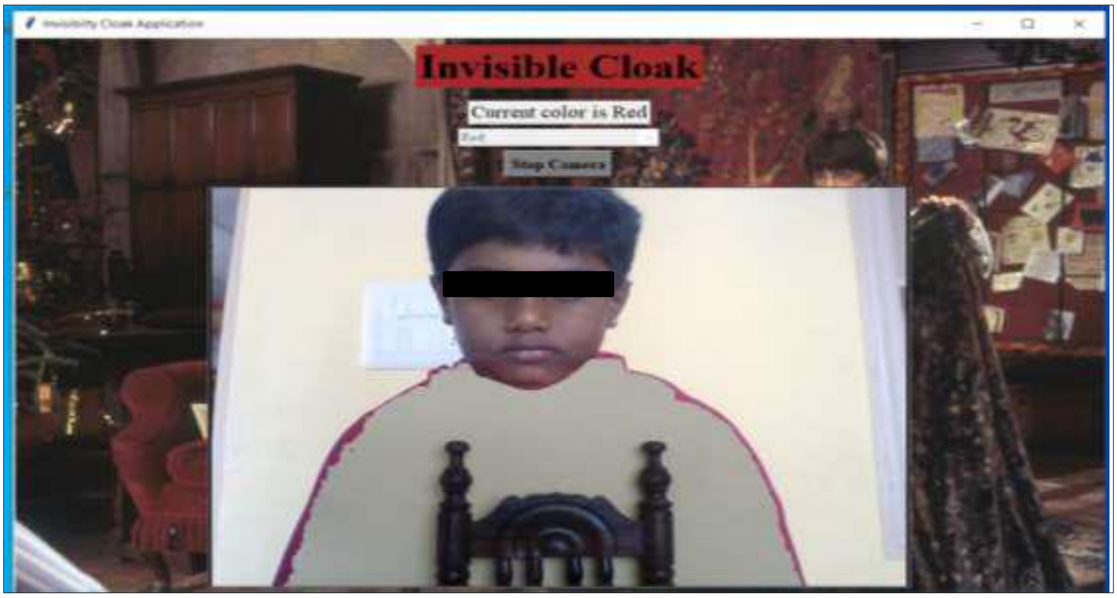

Figure 8 Snapshot of Invisibility Cloak for red colour

As the invisibility cloak application still running, the camera captures the streaming video. Now it detects the red colour object and segments it. The segmented image is combined with the background until the stop camera button is pressed, as shown in the Fig 8.

Figure 9 Snapshot of Invisibility Cloak for blue colour

While the invisibility cloak application is active, the camera continuously captures the streaming video. It then identifies and segments the blue-coloured object in the video stream. The segmented image is seamlessly integrated with the background until the stop camera button is pressed, as depicted in Fig 9.

Figure 10 Snapshot of Invisibility Cloak for green colour

As the invisibility cloak application still running, the camera captures the streaming video. Now it detects the green colour object and segments it. The segmented image is combined with the background until the stop camera button is pressed, as shown in the Fig 10.

6 Conclusion and Future Work

The field of computer vision demonstrates remarkable capabilities in addressing intricate challenges with a high degree of sophistication. This study delves into the fundamentals of color detection techniques, showcasing various approaches to achieve this. The creation of an invisibility cloak is a notable outcome, rendering the wearer invisible within images. The project brings elements of mythology, folklore, and fairy tales to life, incorporating magical aspects into streaming videos. Despite significant progress, computer vision is still evolving and has not reached a stage where it can be readily applied to solve real-life problems. It remains in a developmental phase. Looking ahead, there is potential for widespread application in areas such as Augmented Reality. Specifically, computer vision can find utility in video editing and media to produce captivating and visually stunning content. As technology advances, further enhancements and applications in various domains can be anticipated.

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