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WLS Filter Based Color Transfer in Fabric Images

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***Abstract*— Analytic study of Color design process in a fabric images is a daunting task. A color design process for fabric images can resort to a solution of a color transfer problem based on given color themes. Usually, the color transfer process contains an image segmentation phase and an image construction phase. In existing work, they designed an enhanced novel color transfer method which efficiently applies the color to the fabric images. This process is carried out in two processes, namely, image segmentation and image reconstruction process. Since, the time taken by image decomposition is of higher, in proposed, an attempt is made to develop novel image decomposition process which intellectually reduces the time taken by decomposed image. Weighted Least Squares (WLS) is proposed to filter the image for image decomposition, it produces efficient result. After that, total generalized variation (TGV) regularizer is used to further improve the performance of image decomposition. Here, the TGV regularizer is good at estimating the weak lightness variation of the cartoon component. Numerical results demonstrate that the proposed color transfer method can generate better results for fabric images.**

***Index Terms*— WLS, Weighted Least Squares, TGV, Total Generalized Variation, Color Transfer.**

I. Introduction

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them. It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too.

A. Image Processing Basically Includes the Following Three Steps

- Importing the image with optical scanner or by digital photography

- Analyzing and manipulating the image which includes data compression and image enhancement and spotting patterns that are not to human eyes like satellite photographs.

- Output is the last stage in which result can be altered image or report that is based on image analysis.

B. Purpose of Image Processing

- Visualization - Observe the objects that are not visible.
- Image sharpening and restoration - To create a better image.
- Image retrieval - Seek for the image of interest.
- Measurement of pattern – Measures various objects in an image.
- Image Recognition – Distinguish the objects in an image.

C. Types of Image Processing

The two types of methods used for Image Processing are Analog and Digital Image Processing. Analog or visual techniques of image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques.

The image processing is not just confined to area that has to be studied but on knowledge of analyst. Association is another important tool in image processing through visual techniques. So analysts apply a combination of personal knowledge and collateral data to image processing.

Digital Processing techniques help in manipulation of the digital images by using computers. As raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are Pre- processing, enhancement and display, information extraction.

D. CHARACTERISTICS OF IMAGE PROCESSING

Before going to processing an image, it is converted into a digital form. Digitization includes sampling of image and quantization of sampled values. After converting the image into bit information, processing is performed. This processing technique may be, Image enhancement, Image restoration, and Image compression.

E. WORKING DIAGRAM OF IMAGE PROCESSING

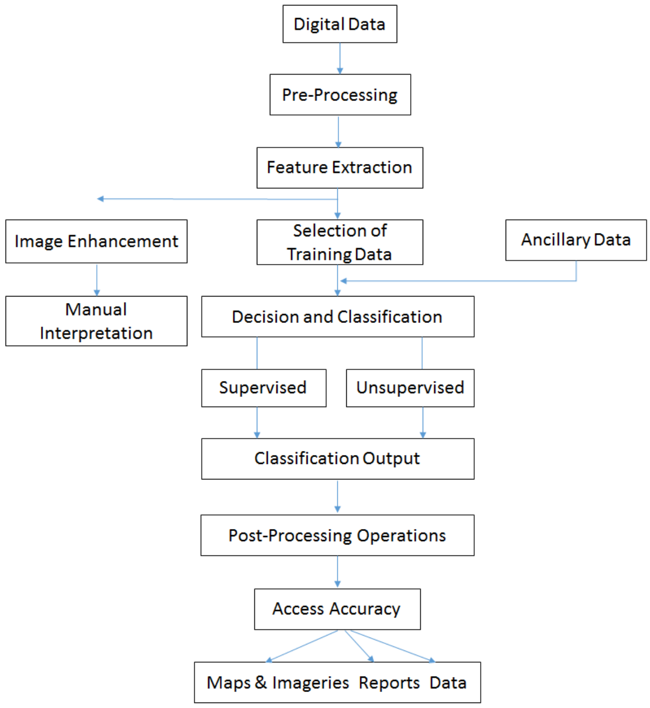

Fig: 1 Working diagram of Image Processing.

F. IMAGE ENHANCEMENT

It refers to accentuation, or sharpening, of image features such as boundaries, or contrast to make a graphic display more useful for display & analysis. This process does not increase the inherent information content in data. It includes gray level & contrast manipulation, noise reduction, edge crispening and sharpening, filtering, interpolation and magnification, pseudo coloring, and so on.

G. IMAGE RESTORATION

It is concerned with filtering the observed image to minimize the effect of degradations. Effectiveness of image restoration depends on the extent and accuracy of the knowledge of degradation process as well as on filter design. Image restoration differs from image enhancement in that the latter is concerned with more extraction or accentuation of image features.

H. IMAGE COMPRESSION

It is concerned with minimizing the number of bits required to represent an image. Application of compression are in broadcast TV, remote sensing via satellite, military communication via aircraft, radar, teleconferencing, facsimile transmission, for educational & business documents, medical images that arise in computer tomography, magnetic resonance imaging and digital radiology, motion, pictures, satellite images, weather maps, geological surveys and so on.

- Text compression – CCITT GROUP3 & GROUP4
- Still image compression – JPEG
- Video image compression - MPEG

I. ADVANTAGES OF IMAGE PROCESSING

- The processing of images is faster and more cost-effective. One needs less time for processing, as well as less film and other photographing equipment.

- It is more ecological to process images. No processing or fixing chemicals are needed to take and process digital images. However, printing inks are essential when printing digital images.

- When shooting a digital image, one can immediately see if the image is good or not.

- Copying a digital image is easy, and the quality of the image stays good unless it is compressed. For instance, saving an image as jpg format compresses the image. By resaving the image as jpg format, the compressed image will be recompressed, and the quality of the image will get worse with every saving.

- Fixing and retouching of images has become easier. In new Photoshop 7, it is possible to smoother face wrinkles with a new Healing Brush Tool in a couple of seconds.

- The expensive reproduction (compared with rastering the image with a repro camera) is faster and cheaper.

- By changing the image format and resolution, the image can be used in a number of media.

II. IMAGE PROCESSING USING MATLAB

MATLAB is a high performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Typical uses include

- Math and computation
- Algorithm development
- Data acquisition

• Modeling, simulation, and prototyping

• Data analysis, exploration, and visualization

• Scientific and engineering graphics

• Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or Fortran. The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation.

MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

A. IMAGE PROCESSING TOOLBOX

Image Processing Toolbox provides a comprehensive set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. You can perform image enhancement, image deblurring, feature detection, noise reduction, image segmentation, spatial transformations, and image registration. Many functions in the toolbox are multithreaded to take advantage of multicore and multiprocessor computers.

Image Processing Toolbox supports a diverse set of image types, including high dynamic range, gigapixel resolution, ICC-compliant color, and tomographic images. Graphical tools let you explore an image, examine a region of pixels, adjust the contrast, create contours or histograms, and manipulate regions of interest (ROIs). With the toolbox algorithms you can restore degraded images, detect and measure features, analyze shapes and textures, and adjust the color balance of images.

B. KEY FEATURES

- Image enhancement, filtering, and deblurring. Image analysis, including segmentation, morphology, feature extraction, and measurement
- Spatial transformations and image registration
- Image transforms, including FFT, DCT, Radon, and fan-beam projection
- Workflows for processing, displaying, and navigating arbitrarily large images
- Modular interactive tools, including ROI selections, histograms, and distance measurements
- ICC color management
- Multidimensional image processing
- Image-sequence and video display
- DICOM import and export

C. IMPORTING AND EXPORTING IMAGES

Image Processing Toolbox supports images generated by a wide range of devices, including digital cameras, satellite and airborne sensors, medical imaging devices, microscopes, telescopes, and other scientific instruments. You can visualize, analyze, and process these images in many data types, including single- and double-precision floating-point and signed and unsigned 8-, 16-, and 32-bit integers.

There are several ways to import and export images into and out of the MATLAB environment for processing. You can use Image Acquisition Toolbox to acquire live images from Web cameras, frame grabbers, DCAM-compatible cameras, and other devices. Using Database Toolbox, you can access images stored in ODBC/JDBC-compliant databases.

MATLAB supports standard data and image formats, including JPEG, JPEG-2000, TIFF, PNG, HDF, HDF-EOS, FITS, Microsoft Excel, ASCII, and binary files. It also supports the multiband image formats BIP and BIL, as used by LANDSAT for example. Low-level I/O and memory mapping functions enable you to develop custom routines for working with any data format.

Image Processing Toolbox supports a number of specialized image file formats. For medical images, it supports the DICOM file format, including associated metadata, as well as the Analyze 7.5 and Interfile formats. The toolbox can also read geospatial images in the NITF format and high dynamic range images in the HDR format.

D. DISPLAYING AND EXPLORING IMAGES

Image Processing Toolbox extends MATLAB graphics to provide image display capabilities that are highly customizable. You can create displays with multiple images in a single window, annotate displays with text and graphics, and create specialized displays such as histograms, profiles, and contour plots.

In addition to display functions, the toolbox provides a suite of interactive tools for exploring images and building GUIs. You can view image information, zoom and pan around the image, and closely examine a region of pixels. You can interactively place and manipulate ROIs, including points, lines, rectangles, polygons, ellipses, and freehand shapes. You can also interactively crop, adjust the contrast, and measure distances. The suite of tools is available within Image Tool or from individual functions that can be used to create customized GUIs.

The toolbox includes tools for displaying video and sequences in either a time-lapsed video viewer or an image montage. Volume visualization tools in MATLAB let you create iso surface displays of multidimensional image data sets.

E. ANALYZING IMAGES

Image Processing Toolbox provides a comprehensive suite of reference-standard algorithms and graphical tools for image analysis tasks such as statistical analysis, feature extraction, and property measurement. Statistical functions let you analyze the general characteristics of an image by:

- Computing the mean or standard deviation
- Determining the intensity values along a line segment
- Displaying an image histogram
- Plotting a profile of intensity value

Edge-detection algorithms let you identify object boundaries in an image. These algorithms include the Sobel, Prewitt, Roberts, Canny, and Laplacian of Gaussian methods. The powerful Canny method can detect true weak edges without being "fooled" by noise.

Image segmentation algorithms determine region boundaries in an image. You can explore many different approaches to image segmentation, including automatic thresholding, edge-based methods, and morphology-based methods such as the watershed transform, often used to segment touching objects.

Morphological operators enable you to detect edges, enhance contrast, remove noise, segment an image into regions, thin regions, or perform skeletonization on regions.

Morphological functions in Image Processing Toolbox include:

- Erosion and dilation
- Opening and closing
- Labeling of connected components
- Watershed segmentation
- Reconstruction
- Distance transform

Image Processing Toolbox also contains advanced image analysis functions that let you:

- Measure the properties of a specified image region, such as the area, center of mass, and bounding box.
- Detect lines and extract line segments from an image using the Hough transform
- Measure properties, such as surface roughness or color variation, using texture analysis functions

F. WORKING WITH LARGE IMAGES

Some images are so large that they are difficult to process and display with standard methods. Image Processing Toolbox provides specific workflows for working with larger images than otherwise possible. Without loading a large image entirely into memory, you can create a reduced-resolution data set (R-Set) that divides an image into spatial tiles and resamples the image at different resolution levels.

This workflow improves performance in image display and navigation. You can use a block processing workflow to apply a function to each distinct block of a large image, which significantly reduces memory use. An additional option for working with large images is to use the Parallel Computing Toolbox.

A very large image might not load in Image Viewer, or if the image does load, zooming and panning can be slow. In either case, creating a reduced resolution data set (R-Set) can improve performance. Use the Image Viewer to navigate an R-Set image the same way you navigate a standard image.

III. SYSTEM DESIGN

Systems design implies a systematic approach to the design of a system. It may take a bottom-up or top-down approach, but either way the process is systematic wherein it takes into account all related variables of the system that needs to be created from the architecture, to the required hardware and software, right down to the data and how it travels and transforms throughout its travel through the system. Systems design then overlaps with systems analysis, systems engineering and systems architecture.

A. DATA FLOW DIAGRAM

• The DFD is also called as bubble chart. It is a simple graphical formalism that can be used to represent a system in terms of input data to the system, various processing carried out on this data, and the output data is generated by this system.

• The data flow diagram (DFD) is one of the most important modeling tools. It is used to model the system components. These components are the system process, the data used by the process, an external entity that interacts with the system and the information flows in the system.

• DFD shows how the information moves through the system and how it is modified by a series of transformations. It is a graphical technique that depicts information flow and the transformations that are applied as data moves from input to output.

• DFD is also known as bubble chart. A DFD may be used to represent a system at any level of abstraction. DFD may be partitioned into levels that represent increasing information flow and functional detail.

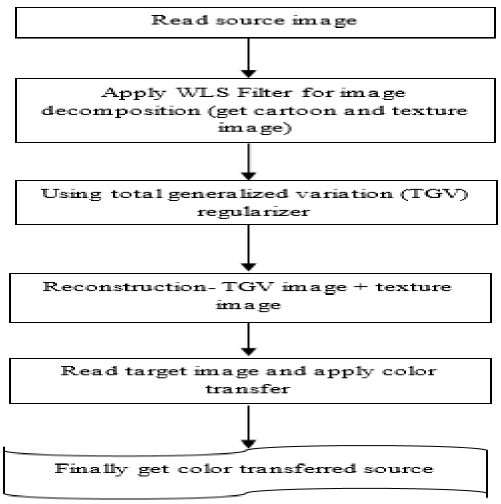

Fig: 2. Data Flow Design Diagram.

B. USE CASE DIAGRAM

A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases.

Use case diagrams are used to gather the requirements of a system including internal and external influences. These requirements are mostly design requirements. Hence, when a system is analyzed to gather its functionalities, use cases are prepared and actors are identified. When the initial task is complete, use case diagrams are modelled to present the outside view. The purpose of use case diagram is to capture the dynamic aspect of a system. Use case diagrams are considered for high level requirement analysis of a system. When the requirements of a system are analyzed, the functionalities are captured in use cases.

The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.

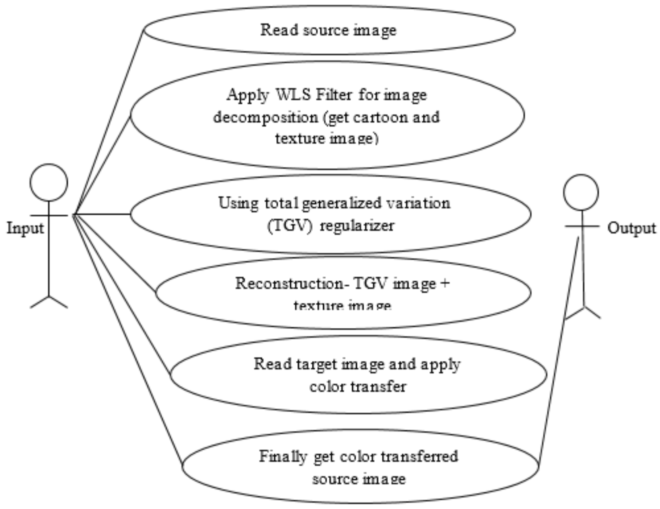

Fig. 3. Use Case Design Diagram

C. BLOCK DIAGRAM

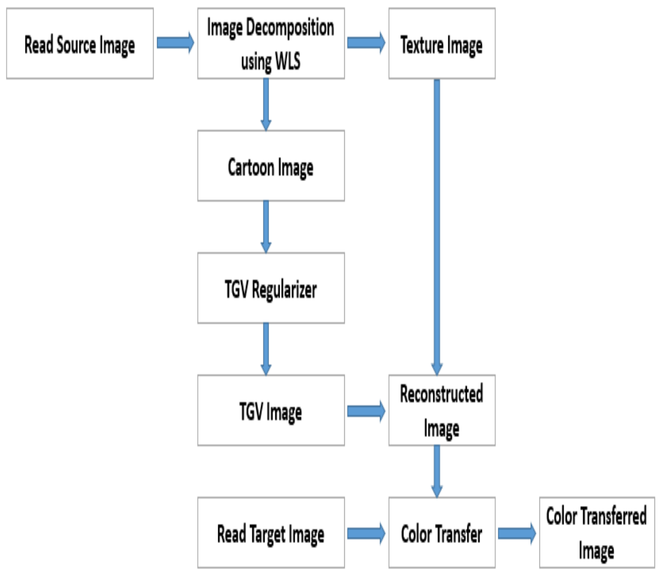

Fig. 4. Block Diagram

D. IMPLEMENTATION

- Source Image Acquisition.
- Image Decomposition using WLS Filter.
- Total Generalized Variation (TGV) Regularizer.
- Reconstruction.
- Color Transfer.

1. Source Image Acquisition
• Image is acquired from Gallery.

2. Image decomposition using WLS Filter
• The aim of image decomposition is to decompose the image I into its cartoon part C and its texture part T, namely, I = C + T. According to the image decomposition theory proposed by Meyer, the cartoon details C are more suitable to be represented in the BV space, and the texture details are more suitable to be represented in the dual space of the BV space, such as the G-, the F- and the E-space.

• The introduction of image decomposition into image segmentation are that, firstly, the cartoon component better coincides with the local piecewise constant assumption of the image segmentation model than the original input image, and, secondly, the texture component of the image can be used in the image construction phase, which makes the color transfer results containing much more fabric texture details.

• Image decomposition process done by using Weighted Least Squares (WLS) filter. This method is used to decompose the image in image decomposition. WLS filter first extract the two base layers that is called as first and second smoothed image. After extract the smoothed images, two details layer are estimated from two base layers. Different levels of details are captured in the corresponding detail layer, with which can easily limit the amplification of unwanted details and enhance the information desirable significantly.

• Finally cartoon image is got from fusing of two base layers and texture image is got from fusing of two detail layers.

3. Total Generalized Variation (TGV) Regularizer

• In this stage, total generalized variation (TGV) regularizer is used for measure the lightness details of the cartoon component.

• The TGV regularizer can better protect soft changing of lightness than the TV regularizer in local regions. Found that the TV regularizer only takes the first derivative of a function into account, but the TGV regularizer takes both the first and the second derivatives into account.

• The TGV regularizer can overcome the staircase drawback of the TV regularizer since higher derivatives can better measure the soft changing of functions.

• Finally got smoothing image using TGV regularizer.

4. Reconstruction

• In reconstruction stage, texture image and TGV regularized image combined to get enhanced source image.

5. Color Transfer

• After reconstruction stage, color transfer is performed between target image and enhanced source image.

IV. RESULTS

A. TEST CASES

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, subassemblies, assemblies and/or a finished product, it is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of test. Each test type addresses a specific testing requirement.

- Unit Testing
- Integration Testing
- Functional Testing
- System Testing
- White Box Testing
- Black Box Testing

B. TEST CASE SCENARIO

Field testing will be performed manually and functional tests will be written in detail.

➢ Test objectives

- All field entries must work properly.
- Pages must be activated from the identified link.
- The entry screen, messages and responses must not be delayed.

➢ Features to be tested

- Verify that the entries are of the correct format
- No duplicate entries should be allowed
- All links should take the user to the correct page.

➢ **Unit Testing**

Unit testing is usually conducted as part of a combined code and unit test phase of the software lifecycle, although it is not uncommon for coding and unit testing to be conducted as two distinct phases.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

➢ **Integration Testing**

Software integration testing is the incremental integration testing of two or more integrated software components on a single platform to produce failures caused by interface defects. The task of the integration test is to check that components or software applications, e.g. components in a software system or – one step up – software applications at the company level – interact without error.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

➢ **Acceptance Testing**

User Acceptance Testing is a critical phase of any project and requires significant participation by the end user. It also ensures that the system meets the functional requirements.

Test Results: All the test cases mentioned above passed successfully. No defects encountered.

C. OUTPUT

Fig. 5. Source Image

Source image is the image that contains the color space that you want your target image to mimic, in this project, given option to select the source image for testing and the above image Fig. 5 is the source image that selected for testing.

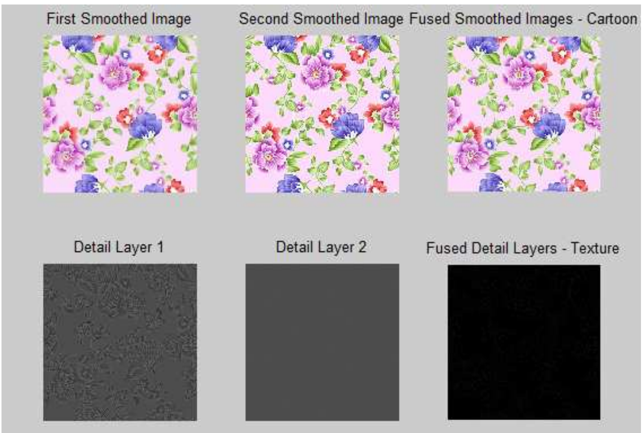

Fig. 6. WLS Filter Working Process Image

In WLS Filter, working process will have two smoothed images and two detail layer, two smoothed images will combine together and get the cartoon image and two detail layer combine together and get the texture image. Fig. 6 is WLS Filter working process image of Fig. 5.

Fig. 7. Cartoon Image

Cartoon image is a smoothed image. That image is getting from decomposition of original image. The cartoon component better coincides with the local piecewise constant assumption of the image segmentation model than the original input image. Fig. 7 is cartoon image of Fig. 5.

Fig. 8. Texture Image

Texture image is the extraction of edge information (Structural content) in original image is called as texture image. The texture component of the image can be used in the image construction phase, which makes the color transfer results containing much more fabric texture details. Fig. 8 is texture image of Fig. 5.

TGV means total generalized variation (TGV) regularizer. TGV regularizer is good at estimating the weak lightness variation of the cartoon component. The total generalized variation (TGV) regularizer is used to further improve the performance of image decomposition. Fig. 9 is TGV image of Fig. 5.

Fig. 9. TGV Image

Reconstructed image is the image of combination of TGV image and texture image. Fig. 10 is reconstructed image, formed in the combination of Fig. 9 and Fig. 8.

Fig. 10. Reconstructed Image

Fig. 11. Target Image

Target image is the image that is used as a pattern to change the color of the source image. Fig 11 is the target image used for color transfer of source image Fig. 5.

Fig. 12. Final Color Transfer Image

Final Color Transfer Image is the image, color pattern of the target image Fig. 11 is applied in the reconstructed image Fig. 10.

V. CONCLUSION

In this project, a novel method for fabric color transfer has been proposed. The fabric design process consists of three main steps such as image decomposition, image reconstruction and color transfer. In image decomposition, image is decomposed into cartoon and texture components by using WLS filter. After that TGV regularizer is used for measure the lightness information from cartoon component. Finally texture image is performed in image reconstruction step with TGV smoothed image and color transfer is explored between target image and enhanced fabric image. Two of these three steps are fully automatic, and it is a low computation cost algorithm to help the user to select and transfer fabric colors from the desired image collection in a real-time operation manner. Experimental results show that there is an innate association between the color-transferred images and the natural images.

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