ISTANBUL KÜLTÜR UNIVERSITY

Graduation Project
ARTIFICIAL INTELLIGENCE SUPPORTED CLOTHING DESIGN

Submitted By

Erencan OYMAK 1700001777
Duygu KEYDAL 1700004157
Kadir Batuhan DEMİR 1700003224

Project Advisor
Prof. Dr. Özgür Koray Şahingöz

Department of Computer Engineering
Istanbul Kultur University

MAY 2022 Spring

ARTIFICIAL INTELLIGENCE SUPPORTED CLOTHING DESIGN

May
2022

ISTANBUL KÜLTÜR UNIVERSITY

Graduation Project
ARTIFICIAL INTELLIGENCE SUPPORTED CLOTHING DESIGN

Submitted By

Erencan OYMAK 1700001777
Duygu KEYDAL 1700004157
Kadir Batuhan DEMİR 1700003224

Advisor
Prof. Dr. Özgür Koray Şahingöz

THE EXAMINATION COMMITTEE

Jury Member		Signature
1.	……..	……..
2.	……..	……..
3.	……..	……..

ABSTRACT

Designers have come to the fore with their originality and their own styles over the years. The original produced.They have shaped the fashion industry with their designs. However, due to the progress of time, designers have become unable to meet the demands of consumers. Since it takes a lot of time to produce an original design, the production process progresses slowly and users are uncomfortable with this situation. Designers are trying to solve this problem with artificial intelligence, which is a part of our lives. Artificial intelligence, which is indispensable in the fields of commerce, art and security, first entered the fashion sector with drawing programs in the 1950s and started to change the fashion sector since the 2000s. In the 1950s, artificial intelligence was used only to create a virtual drawing environment. When the designer made a mistake, he could simply erase the mistake and continue working on the design without having to start the whole design from scratch. These programs have greatly facilitated the work of designers. Designers were now able to draw their designs in a much shorter time. But even this shortened period was not enough for the fashion industry. Designers still could not keep up with the demands of consumers, thanks to scientists who added a different perspective to artificial intelligence in the early 2000s, artificial intelligence is now used not only for drawing but also for designing. It started to produce original designs by preserving the designer's style. It has become able to produce ready-made designs by using features such as object detection and visual processing. In this article, it is aimed to produce new patterns and designs by using artificial intelligence and the effect of artificial intelligence on fashion design and production process.

Keywords: Artificial intelligence, Art, Pattern, Design, Technology.

ÖZET

Tasarımcılar yıllar boyunca özgünlükleri ve kendi stilleri ile ön plana çıkmaktadırlar. Ürettikleri özgün tasarımlar ile moda sektörüne yön vermişlerdir. Fakat zamanın ilerlemesi sebebiyle tasarımcılar, tüketicilerin isteklerini karşılayamaz hale gelmişlerdir. Özgün bir tasarım üretmek çok fazla vakit aldığı için üretim süreci yavaş ilerlemekte ve bu durumdan kullanıcılar rahatsız olmaktadırlar. Tasarımcılar bu sorunu hayatımızın bir parçası olan yapay zekâ ile çözmeye çalışmaktadırlar. Ticaret, sanat ve güvenlik alanlarının vazgeçilmezi olan yapay zekâ ilk olarak 1950'lerde çizim programları ile moda sektörüne giriş yapan yapay zeka 2000'li yıllardan itibaren moda sektörünü değiştirmeye başlamıştır. 1950'lerde yapay zekâ sadece sanal bir çizim ortamı oluşturmak için kullanılıyordu. Tasarımcı bir hata yaptığında tüm tasarıma en baştan başlaması gerekmeden sadece yanlış yaptığı yeri silip tasarımı üzerinde çalışmaya devam edebiliyordu. Bu programlar tasarımcılar işini büyük bir oranda kolaylaştırdı. Tasarımcılar artık çok daha kısa sürede tasarımlarını çizebiliyorlardı. Fakat kısalan bu süre bile moda sektörü için yeterli gelmedi. Tasarımcılar hala tüketicilerin isteklerine yetişemiyordu, 2000'li yılların başında yapay zekaya farklı bir bakış açısı katan bilim insanları sayesinde yapay zekâ artık sadece çizim için değil tasarım üretmek içinde kullanılmaktadır. Tasarımcının stilini koruyarak özgün tasarımlar üretmeye başlamıştır. Nesne algılama, görsel işleme gibi özellikleri kullanılarak hazır tasarımlar üretebilecek hale gelmiştir. Bu makalede yapay zekanın moda tasarımı üzerindeki, ve üretim sürecinde ki etkisi ve yapay zeka kullanılarak yeni desenler, tasarımlar üretmek amaçlanmıştır.

Anahtar Kelimeler: Yapay zekâ, Sanat, Desen, Tasarım, Teknoloji.

ACKNOWLEDGEMENTS

We wish to express our sincere appreciation to our supervisor, Prof. Dr. Özgür Koray Şahingöz for his consistent support and guidance during the running of this project. In addition, we would like to thank Prof. Dr. Güray Yılmaz, who gave us the main idea for the project topic. We would like to express our gratitude and respect to all the lecturers of the Computer Engineering Department who enlightened us with their knowledge throught our undergraduate education life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SYMBOLS & ABBREVIATIONS

AI: Artificial Intelligence

GAN: Generative Adversarial Networks

Tf: TensorFlow

Pd: Pandas

Np: NumPy

Plt: Plot

CNN: Convolutional Neural Network

1. INTRODUCTION

These days, artificial intelligence has become an indispensable part of our lives. We use artificial intelligence in every part of our lives. Since artificial intelligence has entered our lives to such a degree, scientists have aimed to use artificial intelligence in more areas. One of these fields is the fashion design sector, which is one of the most important sectors in our lives. In this study, we will discuss the contributions of artificial intelligence to the fashion design industry and the areas where it is used with the results of the experiment.

1.1. Problem Statement

Nowadays, designers and artists are slow and insufficient to meet the demands of consumers. They spend a long time and work hard to produce original designs and works of art. The decrease in the creativity of the artists and the long duration of inspiration negatively affected the fashion industry. At this point, the artists developed themselves by adapting to the technology and started to use artificial intelligence to shorten the production times, but the drawing programs they used were not enough. They need programs that produce designs.

1.2. Project Purpose

The aim of this project is to develop an artificial intelligence program that produces new images by combining two different images that will help artists and designers. One of the two different images is called the basic image and the other is called the style image. The base image is considered the main layer and is the layer on which the style image is rendered. Almost lifelike content can be produced with Generative Adversarial Networks (GAN), meaning that the designer does not even spend time drawing sketches. With the help of this program, artists and designers will be able to produce new and original content in a much shorter time with less effort. This situation will affect both artists and designers positively, as well as the fashion design industry and consumers.

1.3. Project Scope

A trained model, the VGG-19 model, was used in this project. One of the most important reasons for choosing the VGG-19 model in this project is that it can examine two different images at the same time by processing two different images separately with the layers it has. This shortens the processing time considerably. Generative Adversarial Networks (GAN) algorithm was used for production. After the data is presented to the model, our images are converted into matrices using pixel values. Transformed matrices are processed. Values such as the lengths and widths of the images are calculated. While these processes are taking place, our images lose value. The basic logic of our project starts with finding out at which point the lost values are in the image, when it detects those two different images have lost value at the same point, it overwrites the pixel of the style image at that point on the basic image. This process is repeated for all points, thus combining the two images to form a new image. Google Colab was chosen as the working environment. The reason why Colab is preferred is the virtual Graphical Process Unit (GPU) it provides, it significantly increases the overall working speed of the project and saves time. Another important reason for choosing Colab is that since it can easily connect with Google Drive, the data is kept in the drive and not included in the project, thus reducing the project. Since the data used is related to fashion and art, the product will be a new work related to fashion and art.

1.4. Objectives and Success Criteria of the Project

The success of the project is determined by the quality of the visual it produces. The quality mentioned here is not the quality of the image, but the lines of the image, the compatibility in the merger ratio, the proper fit of the pictures on each other, the correct matching of the value losses found because of the calculations. If the visual created by combining two images by the program does not need to be edited by a designer, this project is considered successful, if the created visual needs to be edited by a designer, the project is considered unsuccessful.

1.5. Report Outline

First of all, it was decided which model to use. For model selection, the working styles, structures and usage areas of the models were investigated. The VGG-19 model

was chosen. Later, similar studies using the VGG-19 model were investigated. Necessary functions have been written for the model to work correctly. Afterwards, attempts were made to find the ideal number of iterations. It has been observed that 50 iterations are sufficient if cubic style images are used as style images, and 350 iterations are generally sufficient in other cases. Afterwards, experimental results, iteration times and numbers are presented in tables. Finally, the general purpose and scope of the project were supported by the data obtained and shed light on future applications.

2. RELATED WORK

There have been many studies on the merging of artificial intelligence and fashion design. However, most of them failed or started to produce different results by deviating from their purpose. The reason for this is that visual processing is suitable for use in many different areas. As a result of the researches, similar studies were reached with the project discussed.

2.1. Existing Systems

Many studies have been done on creating a new image by combining two new images with artificial intelligence. One of them was tried to produce a new design for chair production [3]. But the chair designs produced were unsuccessful. Another similar study was carried out by Natsumi Kato and her colleagues in 2019. Their project is to try to produce clothes with a new design with artificial intelligence. Another of the studies related to visual processing is the project of repairing damaged walls with the GAN algorithm [16]. In the study, the model is trained with many wall images and it is based on estimating the real state of damaged walls. By detecting the solid parts of the model wall, the model gets information about the type, color and shape of the brick. Then, using this information, it tries to produce the real state of the wall by engraving on the damaged part. Another similar study was conducted by Jun-Yan Zhu and colleagues in 2017[10]. It aimed to produce a new visual by bringing together the matched pictures. In 2019, Utkarsh Mall, Noah Snavely and their colleagues used the GAN algorithm in a mass production project connected to the supply chain [14]. The program aimed to produce designs suitable for their environment by perceiving their environment from the photos shared by people. Thus, the designs will be started to be produced according to the wishes of the consumer without the need for them. In 2020, a project has been developed that aims to produce rapid design by giving up original design [6]. By detecting similar clothes, it produces a new outfit by taking certain parts from the two. However, clothes that lost their originality were not demanded much in the fashion industry. This project, which was considered for mass production, did not change anything for consumers. In

2021, a project on fashion design was made using the VGG-19 model [4]. The project performs image processing with the help of GAN algorithm and various formulas. First, it calculates the pixel values of the images, and then transforms these calculated values into a matrix. Then it takes the transpose of these matrices and changes the places of the values. It creates groups by matching the changed values with the values of the other picture. It starts to process on the first image according to the groups formed. Another study on this subject was carried out in 2021 on the combination of art design and artificial intelligence [18]. Artists have come to the fore with their originality and their own styles over the years. However, in cases where the inspiration period is long or they lose their inspiration, the art industry loses these artists. Both art fans are left with high expectations. At this point, it is aimed to produce new works of art thanks to artificial intelligence. Trained with the pictures drawn by the artist, the model thoroughly adopts the artist's style. Later, she reshapes two different images given to her in accordance with the style she learned. Thus, the artist has created a work of art that is both suitable for his own style and unique.

2.2. Overall Problems of Existing Systems

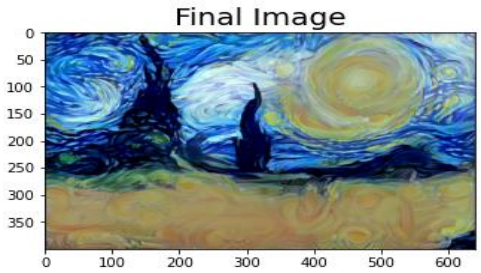
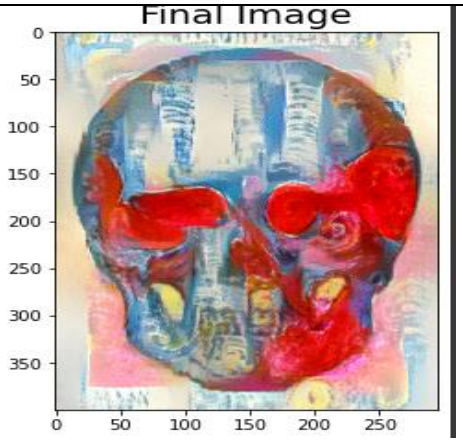
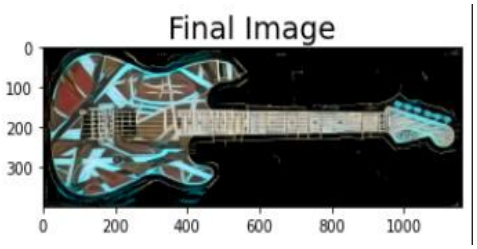
The common problem of these previous studies is the wrong algorithm and wrong model selection. Since the models are trained very extensively, the models cannot make detailed analyzes. For this reason, they make mistakes in many places while processing. The model, which is trained with thousands of murals, tries to predict the intact state of the damaged wall, while trying to make predictions over thousands of options. This causes inaccuracies in the color tone of the brick type. While the developed projects should work with the AttGAN algorithm in general, GAN algorithm is preferred. For this reason, they were insufficient to perceive environmental behaviors.

2.3. Comparison Between Existing and Proposed Method

In the project we have done, visuals in the same style are used for the model to use. This allows the designer to maintain his style and to produce a new design with much less error rate without deviating from the determined style. The outputs created by the projects that have been realized are not at the level to be considered a new design on their

own. Outputs that require a designer to go over them again. Table 2.1 shows the difference between past project and developed project.

Table 2.1 Comparison of Past project and Developed project.

Past Studies	Developed Software
	
	

3. METHODOLOGY

The project uses two images, a base image and a style image. The process aims to produce a new image by printing the style image on the base image. Pixel losses are experienced in the process, and the loss value method is used to capture these pixels.

3.1. Overview of the Dataset/Model

The VGG19 model was used in the software we developed. The reason for using this model is that it is successful in extracting the features of the images clearly.

What is the VGG19 model?

The Vgg-19 model was created in 2015 by the visual geometry group at the University of Oxford and the description of the name is an acronym for their own name. It is a pre-trained model thanks to ImageNet. To explain what ImageNet is, it is a multi-category image database developed for visual object recognition research of hundreds of images. It is open source, available for free to users. Today, it is seen that it comes in TensorFlow and keras frameworks and 80% success is achieved because of the competition, and it has a 7.0% classification error rate.

The VGG19 model is a neural network with a depth of 16 convolution layers, 3 Fully connected layers, 5 MaxPool layers and 1 SoftMax layer. There are other variants of VGG such as VGG11, VGG16 and others [13].

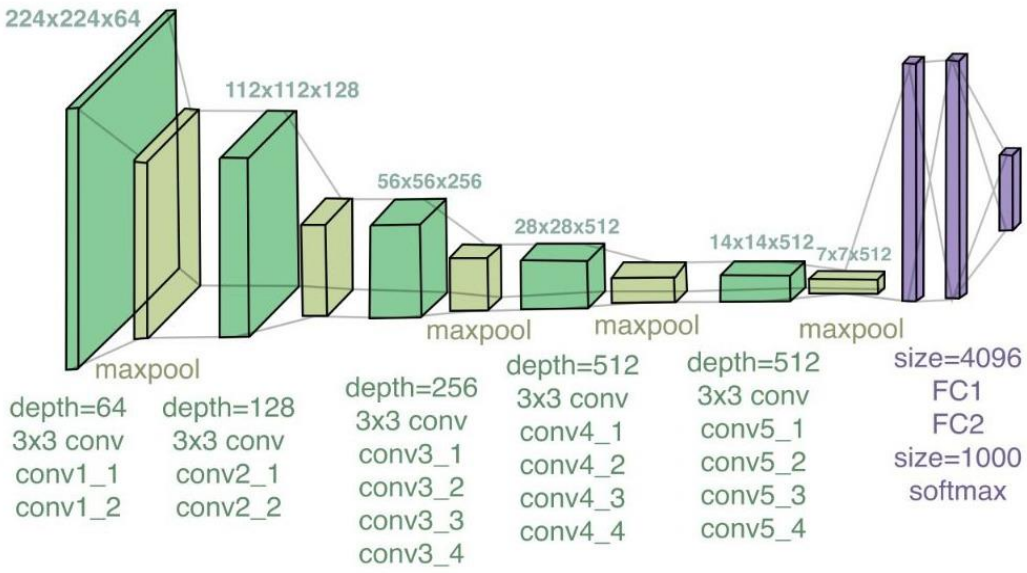


Figure 3.1 VGG Architecture

3.2. Tools and Technology

Tools and technologies used in the software of the project,

• Operating system:

-Windows: While developing this program, windows were used because it is simple to use and more user-friendly and user-friendly than other systems.

-Alternatives/Side Systems: Linux and MacOS

•Programming languages:

-Python: AI programming languages need to be powerful, scalable and easy to read. Python code meets the mentioned requirements. There are other technology stacks in AI-based projects, but Python has proven to be the best programming language for AI. It provides excellent libraries and frameworks for AI and machine learning (ML).

-Alternatives/Side Languages: Java, JavaScript.

• Development Environment:

-Google Colab: Thanks to Google Colab, it allows writing, running and sharing python code without configuration through the browser. It is particularly well suited for machine learning, data analysis, and education.

-Alternatives/Side Environments: Visual Studio Code, Jupyter Notebook.

• Libraries

NumPy: NumPy (Numeric Python) can be used as a math library that allows performing various multidimensional arithmetic operations on arrays. It adds powerful data structures to Python that enable efficient arithmetic using arrays and matrices. Added sequences should be homogeneous.

PyPlot: Pyplot is a submodule of the matplotlib library for Python and functions for plotting 2D graphs. Creating a shape, creating a drawing area, some lines in a drawing area, etc.

Seaborn: Seaborn is an opensource Python library built on matplotlib. It is used for data visualization and exploratory data analysis.

TensorFlow: The TensorFlow Deep Learning library is used for fast numerical computation developed and published by Google. It is a basic library that can be used to build deep learning models directly or to use wrapper libraries that simplify the process built on top of TensorFlow.

Pandas: Pandas provides easy handling of lost data. It is a Python package that provides fast, flexible and meaningful data structures by making it easy to work with "relational" or "tagged" data in processing and analysis.

Figure 3.2 shows the libraries.

```
import pandas as pd
import numpy as np
import os
from keras import backend as K
from keras.preprocessing.image import load_img, save_img, img_to_array
import matplotlib.pyplot as plt
import random
import tensorflow as tf
from keras.applications import vgg19
from keras.models import Model
#from keras import optimizers
from scipy.optimize import fmin_l_bfgs_b
#from keras.applications.vgg19 import VGG19
#WeigthOfVGG19 = '../input/vgg19/vgg19_weights_tf_dim_ordering_tf_kernels_notop.h5'
#vgg19 = VGG19(include_top = False, weights=WeigthOfVGG19)
print(os.listdir("./BitirmeProjesi"))
```

Figure 3.2 Libraries

3.3. Proposed Approach

In the researches carried out in the approach of the project, it was concluded that "style" can change according to the environment in which people live and their personal

thoughts. The individual differences of the designers are limited in producing new patterns, so the effect of deep learning networks in this area has increased significantly, which has helped in this regard. The fact that style can change independently of people as a result of different trials in new areas has opened new avenues. Since the technologies used in the development phase of the project are open source, it is free for developers and researchers. Legally, there is no copyright issue.

The first priority in the requirements of the software is to try on the images of the items used in daily life, the critical point here is to realize that the design on the products we use and see in our lives can be used in more creative and different areas. In this way, anyone who uses the software can make changes according to their own field and use it easily.

If we talk about how to produce an artistic look, it comes up with a smart style algorithm. Style transfer is the practice of recreating the style image as a result of the combination of the base image and the style image. The given base image defines the outlines and the style image will give texture to the final image to be created. The final image is an image that includes the content of the base image and the texture of the style image.

In this section, the working logic of the Neural style transfer will be explained as the basis of the project.

It consists of a combination of deep learning methods. It gives output by adjusting according to random input and output in the training of neural networks. Python stores incoming images as RGB, but since the VGG architecture expects 4-dimensional input, the expand_dim function was used to add a virtual dimension to prevent this. Content and style images given as input have been converted to 224x224x3 size as they require VGG architecture.

The converted image will be input to the VGG network via base image and style image. Two loss values will be stored for images given as input. The stored values will be fed into the VGG model.

In the multi-layer sensor section of the software, the structure of the network, the number of layers and neurons in the layers, the normalization method of the data, the activation function used in the layers, the learning rate, the momentum coefficient, the

number of iterations, the selection of the initial weights were adjusted to give a result picture with the least loss.

The work whose selected style will be used is called the style image, and the image to be converted is called the base image. The picture that is created by transferring the style picture to the content picture is called the final image created. It was concluded that the backgrounds in Figure 3.3 were also processed, resulting in an unsuccessful result.

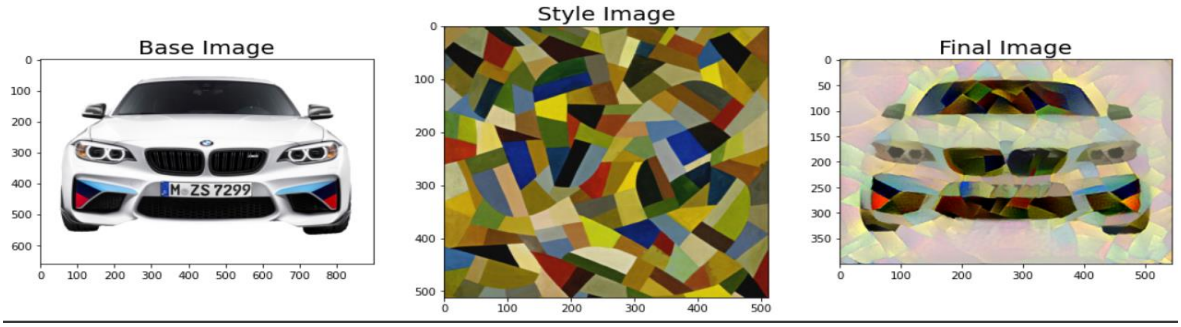


Figure 3.3 Designing of car.

The Figure 3.4, images were chosen because by including edges, points, and every part of the object, changes were seen more clearly in sharp-edged images and for both low and high layer levels. As the importance of the background of the selected Base and Style pictures was noticed in Figure 3.3, a more successful result was obtained by paying attention to the pictures selected in Figure 3.4.

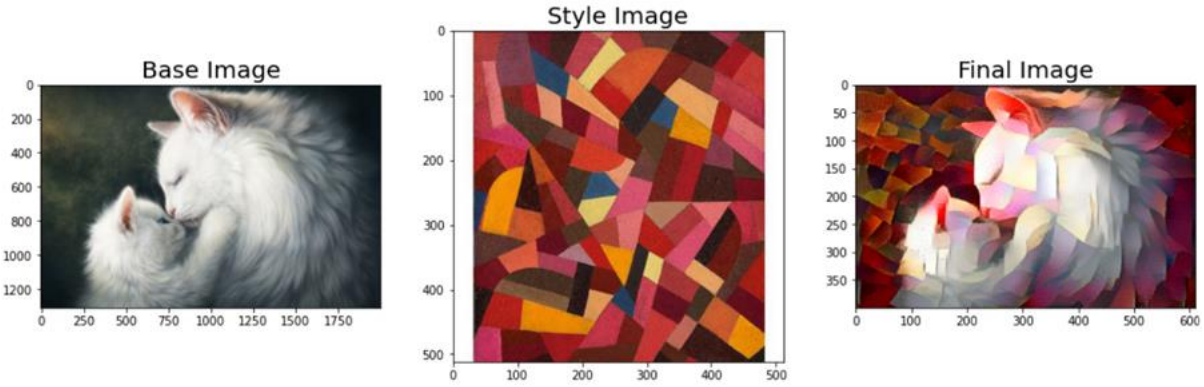


Figure 3.4 The Red cubic cat.

As a result of the software, it was concluded that the operations performed when suitable datasets and patterned images of the same size were selected, yielded successful results. Table 3.1.5 shows the importance and success of the number of iterations.

Table 3.1.5 Change of İteration Numbers.

ITERATION NUMBER		
50	150	350
		
		

4. EXPERIMENTAL RESULTS

Our project aims to produce a new image by combining two different images. Thanks to this process, it reduces the burden of designers in the fashion design industry and shortens the production time. The joining process is done with the VGG-19 model. One of the two combined images is called a "base image" and the second is called a "still image". The merging process starts by transforming the pixels of the images into a matrix and taking their transposes. Data loss is experienced while taking Trans poses, this is called loss value. The loss data in the still image and the base image are matched, and the pixels with the same two loss values are replaced so that the visual processing operation is performed. This process is a single iteration. Many iterations are required to obtain a correct result. The number of iterations required varies depending on the content and design of the base image and still image. In order to determine the ideal iteration number, a general iteration number was determined by making multiple trials.

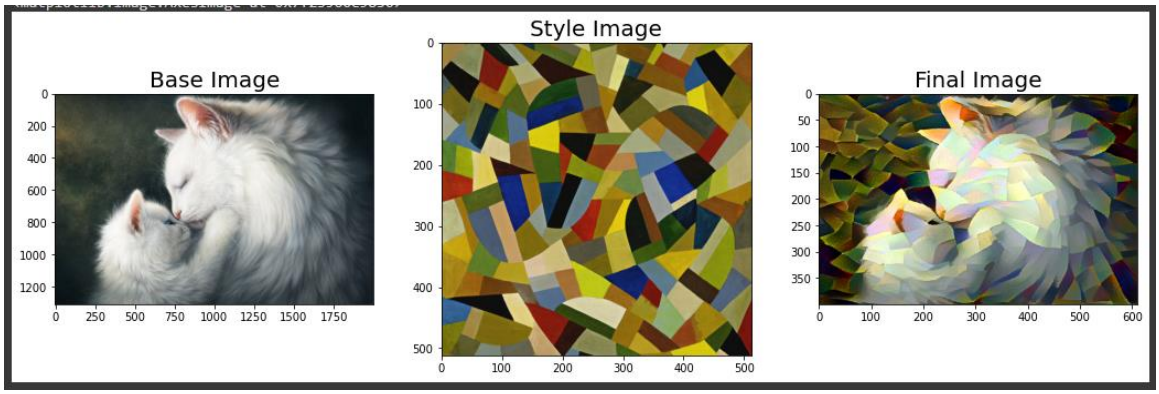


Figure 4.1 50 iterations of the cubic

When using cubic style images as still images, as shown in Figure 4.1, 50 iterations were observed to be sufficient. With the increase in the number of iterations and the increase in the processing time, there is no visible change in the "final image".

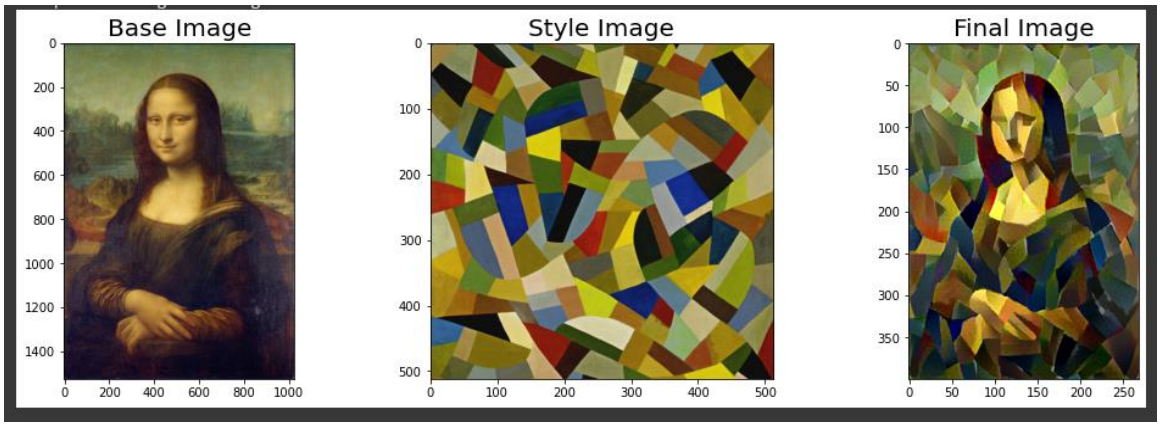


Figure 4.2 50 iterations cubic 2.

The stability of the result created by 50 iterations was confirmed by making other combination examples with the images in the cubic style. As shown in Figure 4.2 , after 50 iterations the style image merges with the base image appropriately.

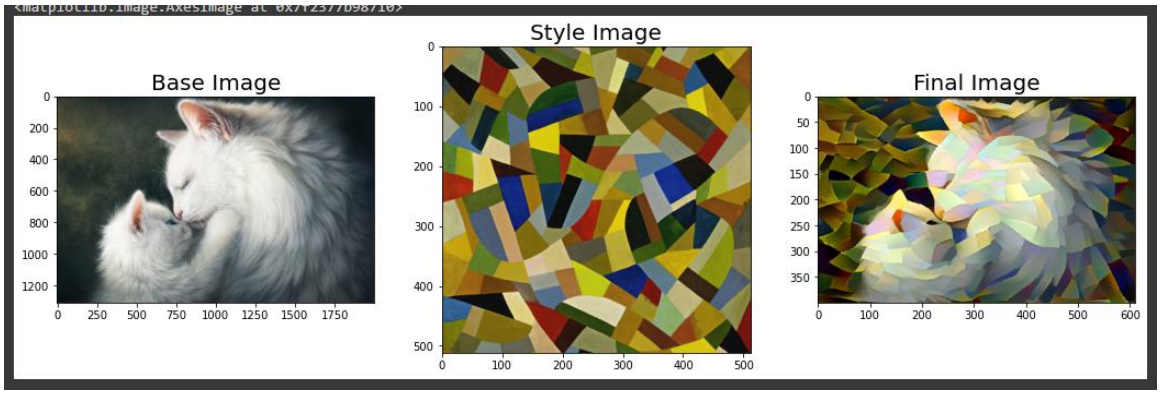


Figure 4.3 100 iterations cubic.

The number of iterations was increased to 100, considering that higher iterations would result in a higher union rate. If 50 iterations are preferred, the processing time is 6.30 minutes, while when 100 iterations are preferred, the processing time increases to 13 minutes. As shown in Figure 4.3, the ideal number of iterations has been determined as 50 in cases where still image is cubical images, depending on variables such as the final image has no change and the processing time is shorter.

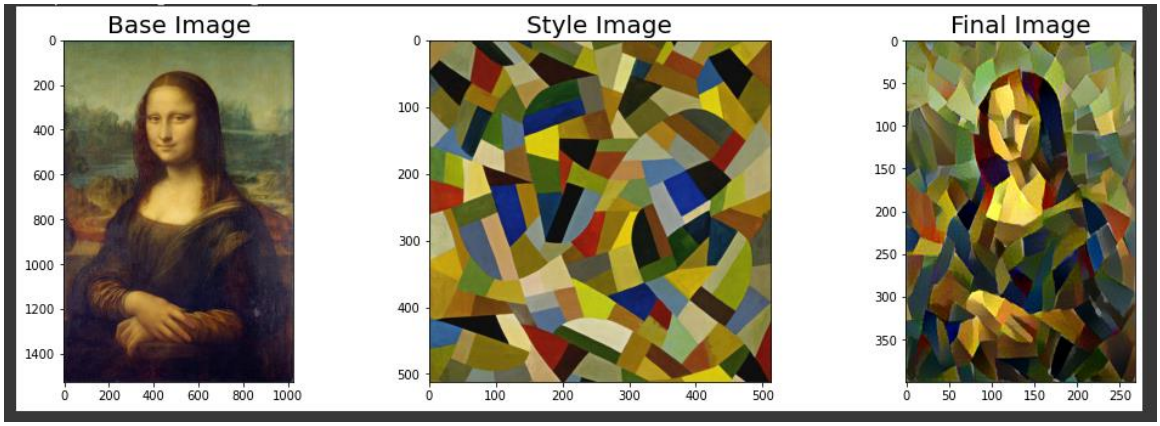


Figure 4.4 100 iterations cubic 2.

It was thought that if an image with more oval lines was chosen as the base image, a different result would be obtained in 100 iterations. As shown in Figure 4.4, it has been observed that the base image's sharp or oval lines will not affect the result, and the cubic style is dominant.

It was observed that 50 iterations were insufficient in the images designed to be printed on t-shirts and similar clothes.

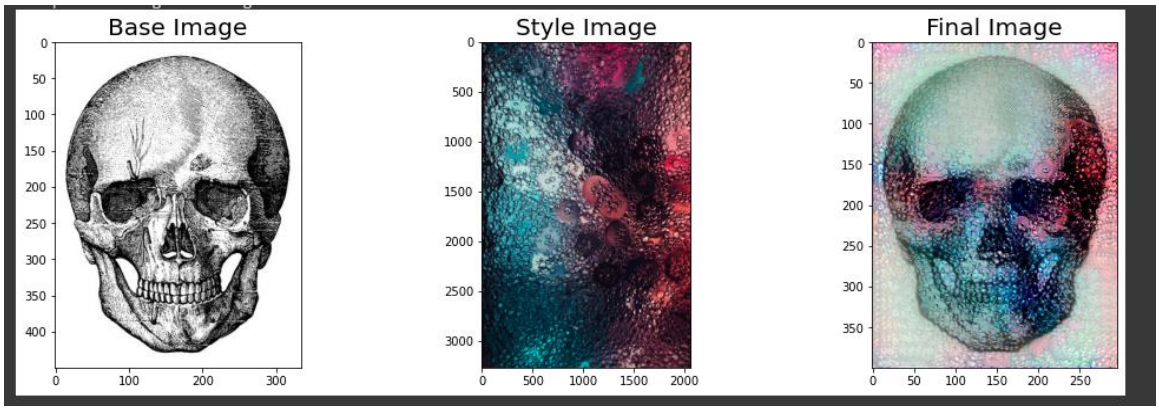


Figure 4.5 Skull 50.

The images preferred by the consumers were analyzed and a base image and a style image were selected according to the patterns they liked on their clothes. Depending on the results of the experiments, these two different images were first processed with 50 iterations. However, consumers were not satisfied with the new image. This is because as

shown in Figure 4.5, base image and style image merge rate is very low. For this reason, the number of iterations is increased and reprocessed.

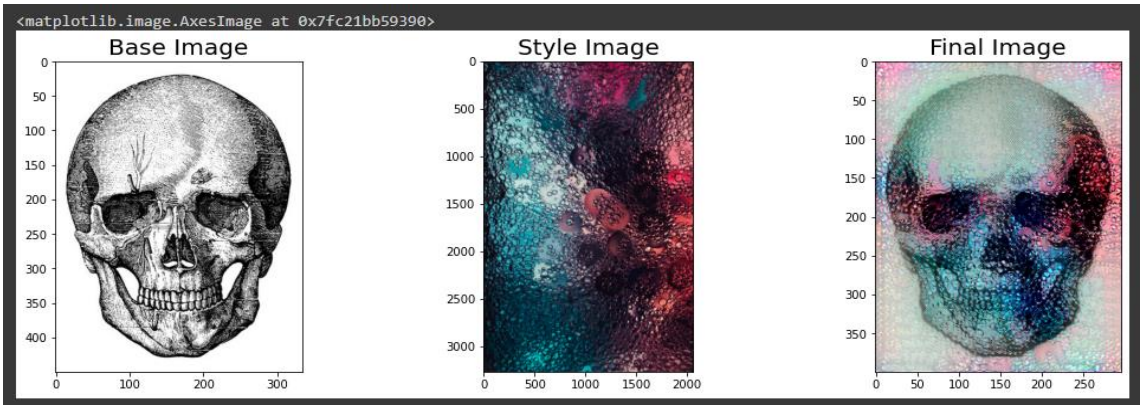


Figure 4.6 Skull 150.

In the second experiment, 150 iterations were tried as the number of iterations. As shown in Figure 4.6, it was thought that a more visual artifact would be obtained by processing the Style image more, but the resulting image was hardly different from the result of the first experiment. Truly little color difference was observed. For this reason, it was decided that 150 iterations were insufficient and a third experiment was performed.

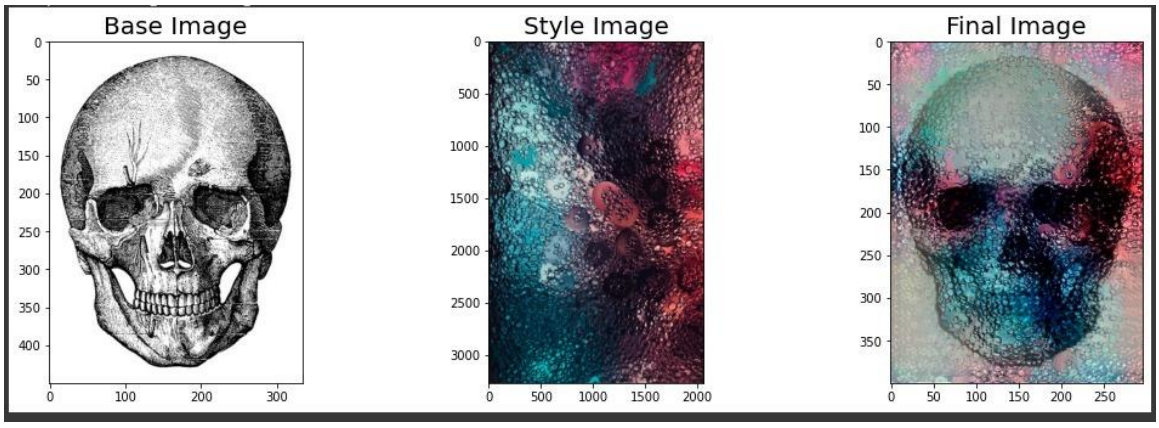


Figure 4.7 Skul 350.

As shown in Figure 4.7, 350 iterations were tried as the number of iterations in the third experiment. It could be seen that the resulting image was much more successful than the results of previous experiments. It has been observed that the tones and texture of the colors of the Style image combine very successfully with the base image.

In the next step of our project, besides producing new patterns to reduce the time of production and supply chain, it was tested whether it could combine two different clothes. Two t-shirts with high sales rates liked by the people were selected and it was observed how the combination of these two t-shirts would be. The fact that t-shirts have their own printing patterns shortens the production process as follows. The new patterns produced are printed on the t-shirt in a virtual environment and it is checked whether it is suitable for production and production starts depending on the situation. This eliminates virtual assembly and shortens production time. The experiment was initially started with 50 iterations.

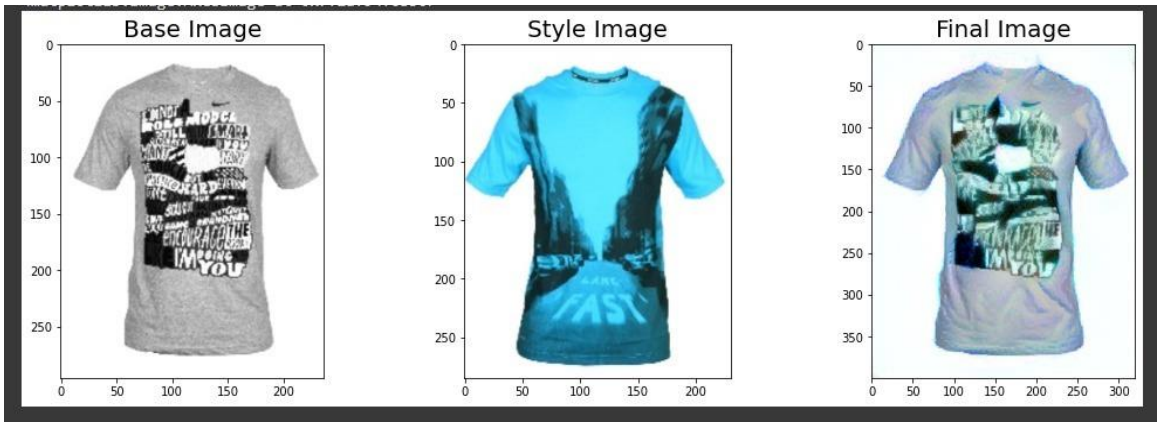


Figure 4.8 Tshirt 50.

As shown in Figure 4.8, because of the first experiment, it was observed that 50 iterations did not have much effect on joining the t-shirts. It is seen that the color of the style image is rendered to the base image to a small degree. However, it is impossible to say a new design for the final image. The print pattern on it is the same as the print pattern of the t-shirt in the base image. It has not been affected by the merging process. The number of iterations has been increased to get more positive results. For the second experiment, 350 iterations were preferred.

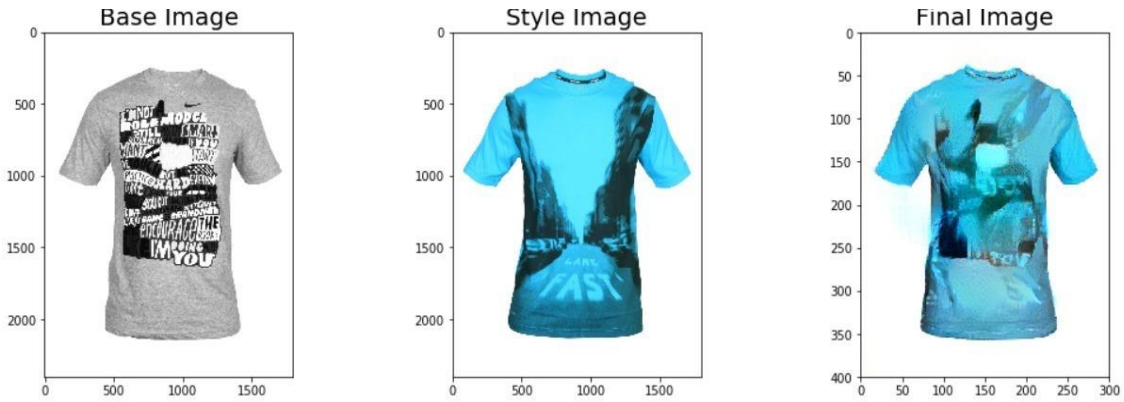


Figure 4.9 T-shirt 350.

As shown in Figure 4.9, As a result of the second experiment, the t-shirt has the color of the style image, although it is different from the base image, but it has a different pattern from the style image in the base image. This proved that 350 iterations were sufficient when combining two different t-shirts.

As a result of the experiments, it was decided that the ideal iteration number of the project was 350 iterations. It was observed that 50 iterations were sufficient in the merging process where the Style image was in cubic style, while 50 iterations were insufficient when using other style images, this result was supported by several different experiments. In general, 350 iterations providing a high success rate were accepted as the ideal iteration.

5. DISCUSSION

The problem to be solved in this project is that it takes too long for fashion designers and artists to produce a product. Artists and fashion designers need a source of inspiration to produce a product. For this reason, it takes a long time to start production. As a solution, a project has been developed that aims to produce a new product by using the original products of the person by using a model that adopts the style of the artist and the designer. The most common mistake in the project is the processing of some mergers into disproportionate areas. This is because the images are not at the same angle. When combining two products in the same style, for example, the car must be at the same angle in the two car images. Thus, the model automatically ignores the background of the images. If one of the vehicles is at another angle, the model detects it in the background and adds it to the process. The successful operation of the project has a positive impact on the fashion design industry. It increases the production speed and shortens the supply chain time.

6. CONCLUSIONS

The problem to be solved in this project is that it takes too long for fashion designers and artists to produce a product. Artists and fashion designers need a source of inspiration to produce a product. For this reason, it takes a long time to start production. As a solution, a project has been developed that aims to produce a new product by using the original products of the person by using a model that adopts the style of the artist and the designer. The most common mistake in the project is the processing of some mergers into disproportionate areas. This is because the images are not at the same angle. When combining two products in the same style, for example, the car must be at the same angle in the two car images. Thus, the model automatically ignores the background of the images. If one of the vehicles is at another angle, the model detects it in the background and adds it to the process. The successful operation of the project has a positive impact on the fashion design industry. It increases the production speed and shortens the supply chain time.

The fact that style can change independently of people as a result of different trials in new areas has opened new avenues. It has been concluded that the concept of "style" can change according to what people observe in their environment and can change according to their personal thoughts. Since designers are limited in time and creative new patterns are limited from time to time, the style generation tool that has been opened with the development of technology has become a great need. In the developed system, it is aimed to get more creative outputs apart from the "personal thoughts" of the concept of style. The patterns and shapes output by AI are intended to be a tool to present preliminary ideas to the designer. The priority of our project is to try on items used in daily life and to offer solutions to the designer with different patterns. Users who use the software in different sectors can select, change and easily use their unique base image and texture image. To increase the quality of the new model, and to increase its originality, some optimization algorithms such as genetic algorithms or similar evolutionary models can be used with this huge range of the searching capability it is believed to reach very stylish models.

7. LITERATURE REVIEW

In recent years, many studies on Pattern Production have started. A lot of research has been done and research articles have been produced on the relationship between Deep Learning approaches and artificial intelligence and art. Machines are creating great changes in our lives as they did centuries ago.

In 2014, DeepDream was developed by Alexander Mordvintsev for a competition and published by Google in 2015. DeepDream uses convolutional neural network to detect patterns in images and enhance images through algorithmic pareidolia. It is a computer program that produces the visualization of image recognition by generating different images because of the processed images.

In 2019, Chandadevi Giri, Sheenam Jain, Xianyi Zeng, Pascal Bruniaux explained why artificial intelligence is needed in the fashion and apparel industry, and the positive effects it will provide because of its use [5]. One of the most frequently encountered problems in the fashion and ready-made clothing industry is the supply problem that arises when the mold is not suitable for the pattern ordered by the consumer. At this point, artificial intelligence trained with machine learning calculates standard patterns and deviations from standard patterns to a certain extent. Fuzzy logic and Genetic (Gan) algorithm are used to make the necessary calculations. Fuzzy logic saves the classification of patterns such as narrow and wide patterns, which provides clear results, and enables the creation of patterns such as a little narrow and a little wide. These created data are processed with the Gan algorithm and taught to artificial intelligence. Afterwards, artificial intelligence enables the production of products suitable for this data. Another point where artificial intelligence will contribute to the fashion and apparel industry is model estimation. Accelerates supply chain operation by predicting product production based on top-selling, searched models.

In 2022, Han Yan, Haijun Zhang, Linlin Liu, Dongliang Zhou, Xiaofei Xu, Zhao Zhang, Shuicheng Yan explained the shortcomings of artificial intelligence currently used for the traditional fashion industry, and the development of new models to eliminate these shortcomings, and what exactly these models do [9]. Traditional models are used to assist designers, but they do not speed up the process as much as they should. While the model is expected to produce a preliminary sketch, determine the texture, and yarn

dimensions suitable for the produced sketch, the models can only produce a sample sketch. For this reason, the designer must make the necessary classifications. The new models developed work separately. The first model produces only the sketch, the second model determines the texture suitable for the sketch obtained. The designer, on the other hand, only makes the final checks and drawings. Thus, the design and production process are significantly accelerated.

In 2019, Utkarsh Mall, Noah Snavely, Bharath Hariharan, Kavita Bala, Kevin Matzen explained the process of discovering fashion trends and events with artificial intelligence [14]. Most of the human population actively uses social media, sharing their pictures and videos. From these shared videos and photos, a lot of information about their environment can be accessed. At this point, analysis is made using artificial intelligence and object recognition, color and shape detection features. By looking around, information about the location's weather is predicted and recorded. Different photos in the same location are compared and the data is recorded. These recorded data include how people in the specified position dress and what kind of fabrics they prefer. For example, in Japan (Golden week), artificial intelligence compares shared photos, tags, people's clothes and the color of their clothes. As a result of this analysis, it reaches the conclusion that people wear yellow clothes during the dates called "Golden Week".

In 2021, Zhang Han explained the importance and working logic of the combination of artificial intelligence and art design [18]. As a result of the combination of artificial intelligence used in information gathering and art design, new works of art can be created. A painting or photograph is combined with a work of art to produce a new result. This application paves the way for art design. In traditional art design, the inspiration of the designer is limited, but the design combined with artificial intelligence has an unlimited production capacity. In this way, the designer can produce unique designs without forcing himself too much. While the components such as inspiration, tools to be used, preferred techniques, and design are all determined by the designer in traditional art design, situational semantic understanding, data collection by the artist, modeling, processing and design are done by the computer in art design with artificial intelligence. It generates random designs using the data collected by the designer.

In 2021, Bingyang Niu, Yuxuan Ma and Yali Qi shows the style transfer of image target region with deep learning. VGG-19 model is used in this article [4]. Due to the layers provided by the VGG-19' model, the operations were carried out faster. Style transfer of image target contains two specific inputs. These are called content map (main input) and target area mask map (condition input/style).

Pixels are used for image processing. Matrices are created from the pixels of the images and an AND operation is performed between these two matrices. It can be said that the new matrix formed is the basic state of the output. VGG-19 first calculates the loss of the content and processes the content by considering the height and width of the content in different layers in the required formula. It then calculates the loss of the style. As a result of the calculations, it produces the new picture by matching at the points where the loss values are the same.

In 2019, Natsumi Kato, Hiroyuki Osone, Kotaro Oomori, Chun Wei Ooi, and Yoichi Ochiai explained how the use of Generative Adversarial Networks (GANs) contributed to clothing design and how it worked [12]. Designers stand out for their originality and style, but maintaining this originality and style is one of the biggest challenges of being a designer. At this point, machine learning offers designers original and style-preserved products. With the deep learning method, which is one of the sub-titles of machine learning, all the designs of the designer until today are taught to the model. The trained model does not go beyond these data and uses them to produce new designs in the same style. At this stage, GAN offers the designer a unique design with features such as high resolution, painting, creating specific and realistic images between designs while translating from image to image.

In 2020, Chenxi Yuan and Mohsen Moghaddam announced that Generative Adversarial Networks (GANs) offered a faster and more automated mass production opportunity by compromising originality by considering the effect of Generative Adversarial Networks (GANs) on clothing design from a different perspective [6]. The issue of producing different and original designs with GANs has been discussed in many articles until today, but the issue of compromising originality has never been discussed. This article describes how to provide a fast mass production process according to the behavior, appearance and wishes of consumers rather than originality. For this, Attribute

Generative Adversarial Networks (AttGAN), a type of GAN, is used. AttGAN provides an automatic production process without the need for a designer by analyzing the personal quantities such as beards, mustaches, skin colors and hair colors of the individuals in the images presented to the model, predicting the product style they may want and using the clothes in the data set. The resulting design is edited by the designer and started to be produced.

In 2018, Xuehui Wu, Jie Shao, Lianli Gao, and Heng Tao Shen explain how to convert from unpaired image to image [15]. Image-to-image translation, aimed at learning a mapping from one area to another, has a wide range of applications. They use the VGG-19 model, which is a pre-trained model. Also, VGG-19 is a CNN model with 19 layers. Both images are encoded into a shared deep space via a pre-trained VGG-19 network and then use two decoders to individually transform them into corresponding image fields. Additionally, they offer skip-the-link block and self-reconfiguration loss to facilitate mapping. Experimental results show that the proposed SDSGAN has both numerical and perceptual advantages over existing methods.

In 2017, a group of people solved the image-to-image translation problem by teaching the mapping between two pairs of images. This study was done by Jun-Yan Zhu, Taesung Park, Philip Isola and Alexei A. Efros [10]. The image pair will be aligned and inverted. The images lose their value when this action happens. In this case, the system makes a pair of these values. In this way, it can see which pixel should match which pixel. The Gan algorithm is the most common technique for teaching the model.

In 2021 Yahya Ibrahim, Blazs Nagy and Csaba Benedek explain the Gan algorithm's working principle with a Wall restoration application [16]. This application's aim is straighten out the painted walls with predicting the wall's original form.

Application contain three learning process. These are brick, mortar and occluded regions respectively. Application's first step Gan algorithm predict the brick's and mortar's type. When it predict the their type firstly perceive the RGB colors after that perceive the shape of bricks. The predict process Works like this: firstly perceive the unpainted brick's shape, size and color then perceive the mortar's color and type. Then try to give similar output that fit to painted part.

If Wall contain more than one painted part the algorithm try to straighten out at the same time. In this situation application Works slowly, because Gan try to predict too many information.

In 2022 Masha Valizadeh and Sarah Jeannette Wolff clarify the convolutional neural network (CNN) [11]. Masha and Sarah use convolution neural network for additive manufacturing. They explain what is additive manufacturing (AM), what is machine learning and what is convolutional neural network and its architecture.

Additive manufacturing or 3D printing is designing a n layer data and print it. CNN using deep learning techniques. In application model have shape, color, size and extra details. In CNN every neural network works on different information. Every neural network pooling the data. This situation provide a true prediction ratio. When application try to print a model, CNN predict the model's size, color and shape before the user enter informations. In this way AM process completed in a short time.

According to the literature study, producing different patterns for designers facilitated the designer as it was created in a short time and with low capital thanks to the artificial intelligence used. In this section, both a summary of the studies in the literature and a detailed comparison table are made.

8. FUTURE WORKS

In this section, the areas where style design programs can be encountered in the future are mentioned.

With the development of the project, it has been observed that our own outputs, which are produced by combining the texture of the base image and the style image, also give successful results when tested on the items used in daily life and bring a different perspective.

The project can be developed in later stages and modified to be used in different areas. In the future, a useful software can be developed by automatically selecting the most popular products and patterns with the python object detection feature. The software can be used in different industries. It will be a useful tool for designers and will bring customization and differences, especially in fashion sense.

9. REFERENCES

[1]– [18]

[1] A. Aggarwal, M. Mittal, and G. Battineni, “Generative adversarial network: An overview of theory and applications,” *International Journal of Information Management Data Insights*, vol. 1, no. 1. Elsevier Ltd, Apr. 01, 2021. doi: 10.1016/j.jjimei.2020.100004.

[2] A. Bagaskara and M. Suryanegara, “Evaluation of VGG-16 and VGG-19 Deep Learning Architecture for Classifying Dementia People,” in *Proceedings - 2021 4th International Conference on Computer and Informatics Engineering: IT-Based Digital Industrial Innovation for the Welfare of Society, IC2IE 2021*, 2021, pp. 1–4. doi: 10.1109/IC2IE53219.2021.9649132.

[3] A. Radford, L. Metz, and S. Chintala, “Unsupervised representation learning with deep convolutional generative adversarial networks,” 2016.

[4] B. Niu, Y. Ma, and Y. Qi, “Style Transfer of Image Target Region Based on Deep Learning,” in *Proceedings - 2021 6th International Symposium on Computer and Information Processing Technology, ISCIPT 2021*, 2021, pp. 486–489. doi: 10.1109/ISCIPT53667.2021.00104.

[5] C. Giri, S. Jain, X. Zeng, and P. Bruniaux, “A Detailed Review of Artificial Intelligence Applied in the Fashion and Apparel Industry,” *IEEE Access*, vol. 7, pp. 95376–95396, 2019, doi: 10.1109/ACCESS.2019.2928979.

[6] C. Yuan and M. Moghaddam, “Garment Design with Generative Adversarial Networks,” Jul. 2020, [Online]. Available: http://arxiv.org/abs/2007.10947

[7] E. Csanák, “13 th INTERNATIONAL SCIENTIFIC-PROFESSIONAL SYMPOSIUM TEXTILE SCIENCE AND ECONOMY 18 th,” 2020, doi: 10.6084/m9.figshare.14540733.

[8] H. Wang and K. Rasheed, “Artificial Intelligence in Clothing Fashion.” [Online]. Available: http://glamstorm.com/en

[9] H. Yan *et al.*, “Toward Intelligent Design: An AI-based Fashion Designer Using Generative Adversarial Networks Aided by Sketch and Rendering Generators,” *IEEE Transactions on Multimedia*, 2022, doi: 10.1109/TMM.2022.3146010.

[10] J.-Y. Zhu, T. Park, P. Isola, A. A. Efros, and B. A. Research, “Unpaired Image-to-Image Translation using Cycle-Consistent Adversarial Networks Monet Photos.” [Online]. Available: https://github.com/junyanz/CycleGAN.

[11] M. Valizadeh and S. J. Wolff, “Convolutional Neural Network applications in additive manufacturing: A review,” *Advances in Industrial and Manufacturing Engineering*, vol. 4. Elsevier B.V., May 01, 2022. doi: 10.1016/j.aime.2022.100072.

[12] N. Kato, H. Osone, K. Oomori, C. W. Ooi, and Y. Ochiai, “Gans-based clothes design: pattern maker is all you need to design clothing,” Mar. 2019. doi: 10.1145/3311823.3311863.

[13] Rohit Thakur, Step by step VGG16 implementation in Keras for beginners, https://towardsdatascience.com/step-by-step-vgg16-implementation-in-keras-for-beginners-a833c686ae6c

[14] U. Mall, K. Matzen, B. Hariharan, N. Snavely, and K. Bala, “Geostyle: Discovering fashion trends and events,” in *Proceedings of the IEEE International Conference on Computer Vision*, Oct. 2019, vol. 2019-October, pp. 411–420. doi: 10.1109/ICCV.2019.00050.

[15] X. Wu, J. Shao, L. Gao, and H. T. Shen, “Unpaired Image-to-Image Translation from Shared Deep Space,” in *Proceedings - International Conference on Image Processing, ICIP*, Aug. 2018, pp. 2127–2131. doi: 10.1109/ICIP.2018.8451250.

[16] Y. Ibrahim, B. Nagy, and C. Benedek, “A GAN-based blind inpainting method for masonry wall images,” in *Proceedings - International Conference on Pattern Recognition*, 2020, pp. 3178–3185. doi: 10.1109/ICPR48806.2021.9413009.

[17] Y. Liang, S. H. Lee, and J. E. Workman, “Implementation of Artificial Intelligence in Fashion: Are Consumers Ready?” *Clothing and Textiles Research Journal*, vol. 38, no. 1, pp. 3–18, Jan. 2020, doi: 10.1177/0887302X19873437.

[18] Z. Han, “Combined Development of Artificial Intelligence and Art Design,” in *2021 IEEE 6th International Conference on Intelligent Computing and Signal Processing, ICSP 2021*, Apr. 2021, pp. 1023–1026. doi: 10.1109/ICSP51882.2021.9408896.