# Virtual Wardrobe for Stitch-Fix


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# Overview

Trying on clothes once you receive a fix-box is one of the most time-consuming tasks. Usually long waiting periods have to be taken into account, for example trying out the cloths and returning back the ones not fitting or liked. Reducing this time and helping people to put on a large collection of garments in reduced time was a relevant motivation for this thesis. Using modern technology, the try-on experience can be drastically improved.

Even in web shops people are very sceptic buying clothes because a try-on of clothes is not possible. The techniques discussed in this paper can enhance the shopping experience. It even offers customers a more precise representation than 2D images of the cloth they are willing to buy and therefore this may also reduce the amount of goods the buyers return.

In this thesis we will introduce a Virtual Dressing Room, which offers a solution for the mentioned aspects. The module is based on a mirror, represented by a display that outputs the image of the camera. If a person is giving images of them, the person will be able to select desired clothes. The selected garment is then virtually superimposed with the image recorded by the camera. In general, this technique can be categorized under augmented reality (AR), where a real-time view of the reality is extended and furthermore overlaid with additional information. This paper mainly focuses on the applications in cloth stores

# Goals

The aim of the thesis is to create a Virtual Dressing Room that realistically reflects the appearance and the behavior of garment. It should further adapt to specific bodies of different persons depending on their body measurements. This will be one of the main challenges since the pieces of cloth should correctly fit to as many persons as possible independent of their individual dimensions

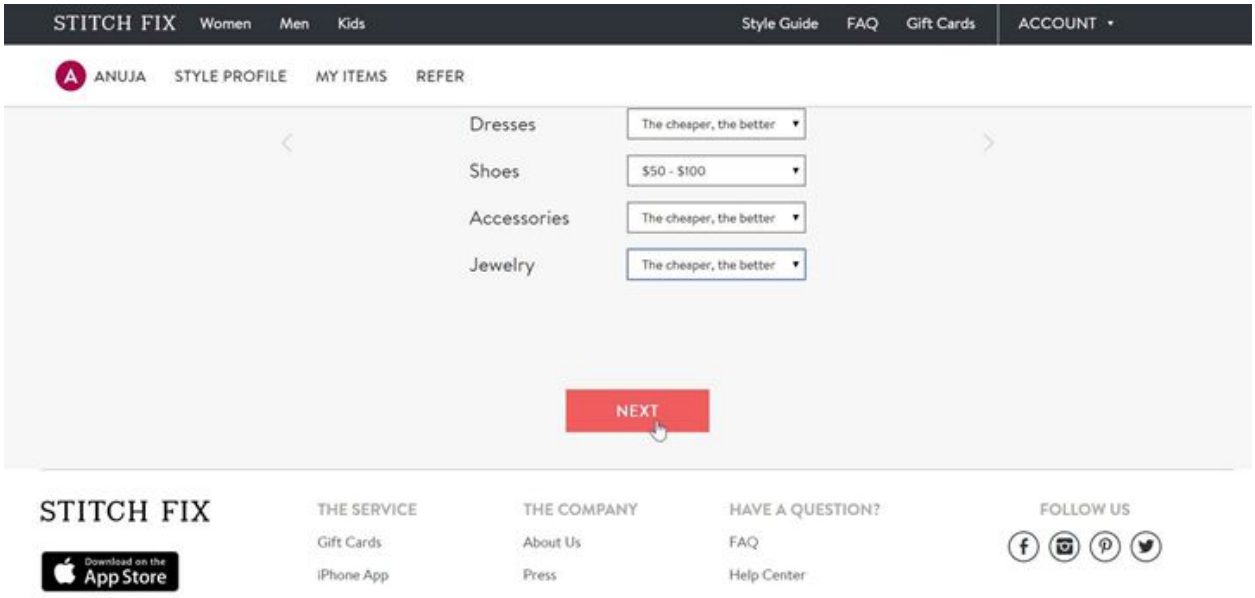
# Use Cases

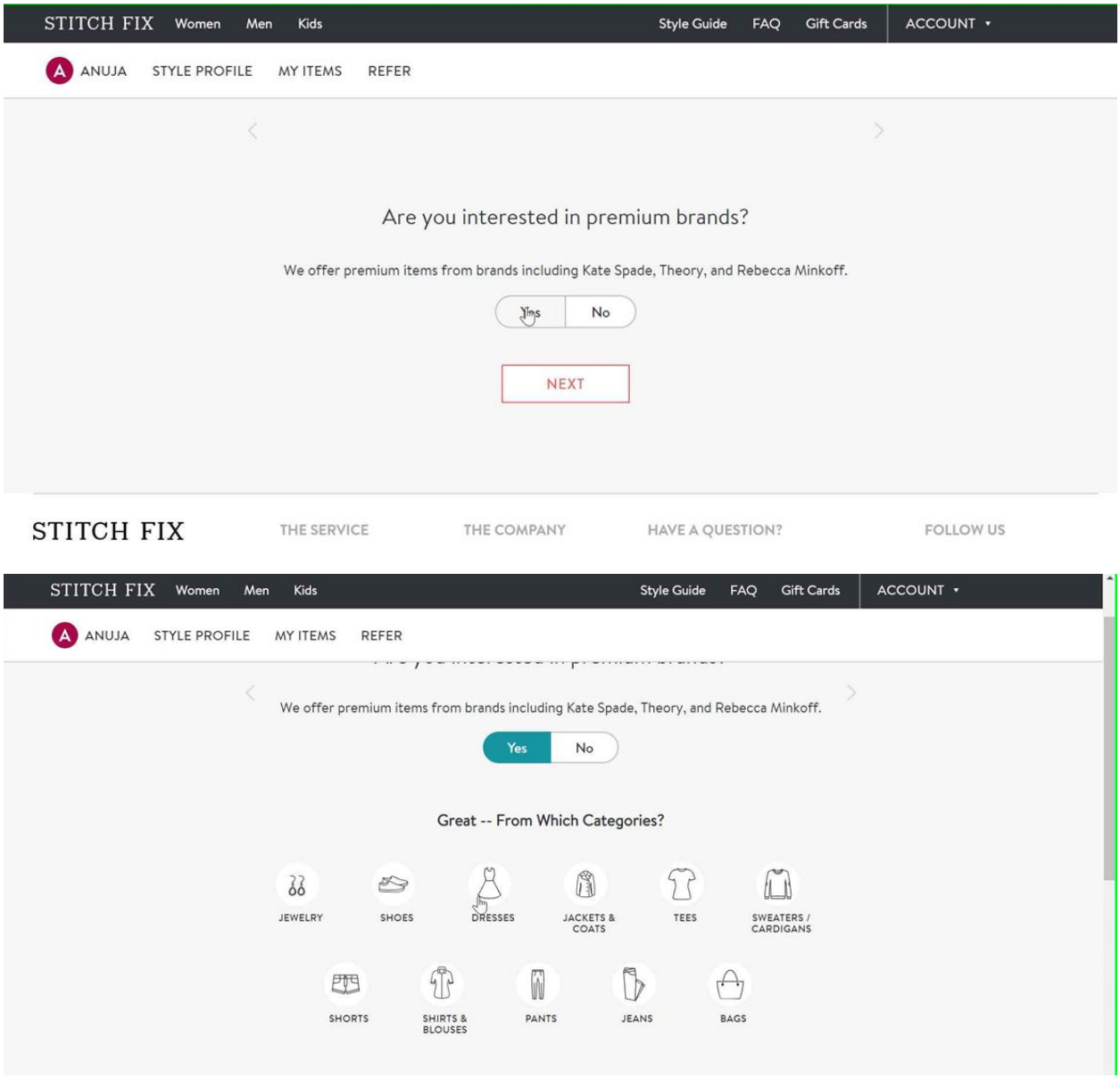
**Time-consumption-**Decreasing the fit time for customer, reduction in delivery revenue and  inventory management

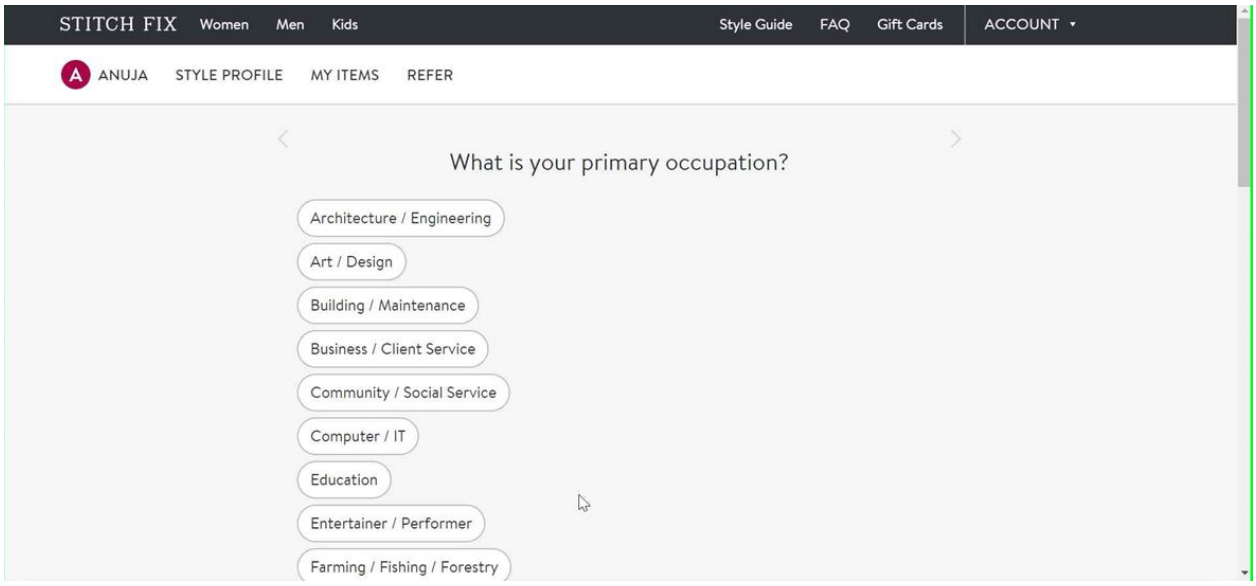
**Clothing fit and size-**Recommendation for the customer as per the shape and size

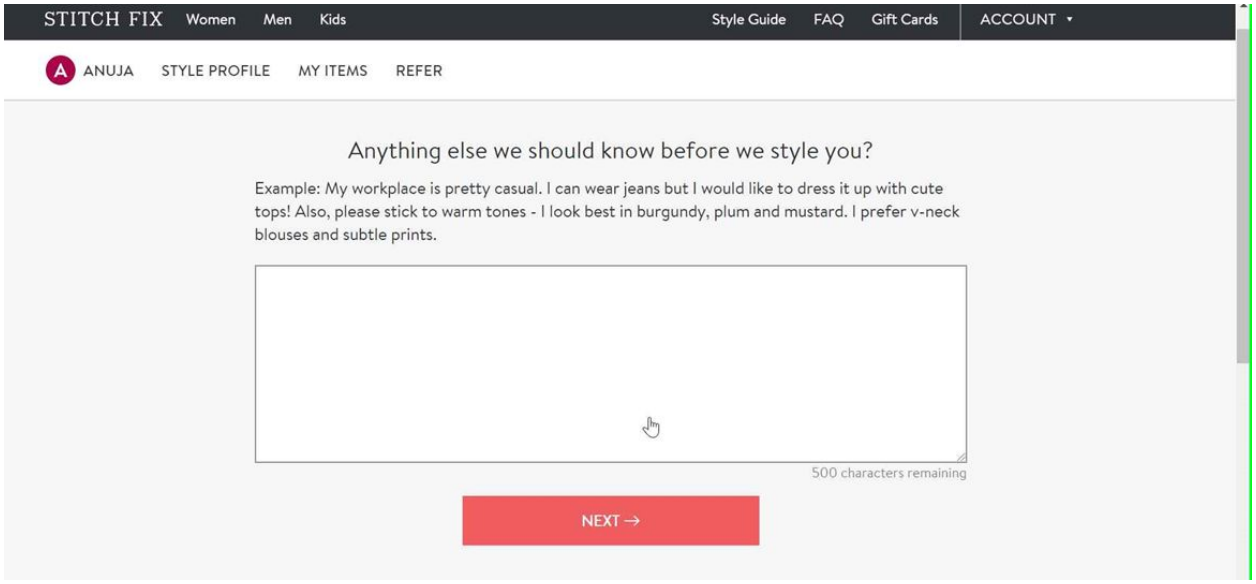
# Recommendation System:

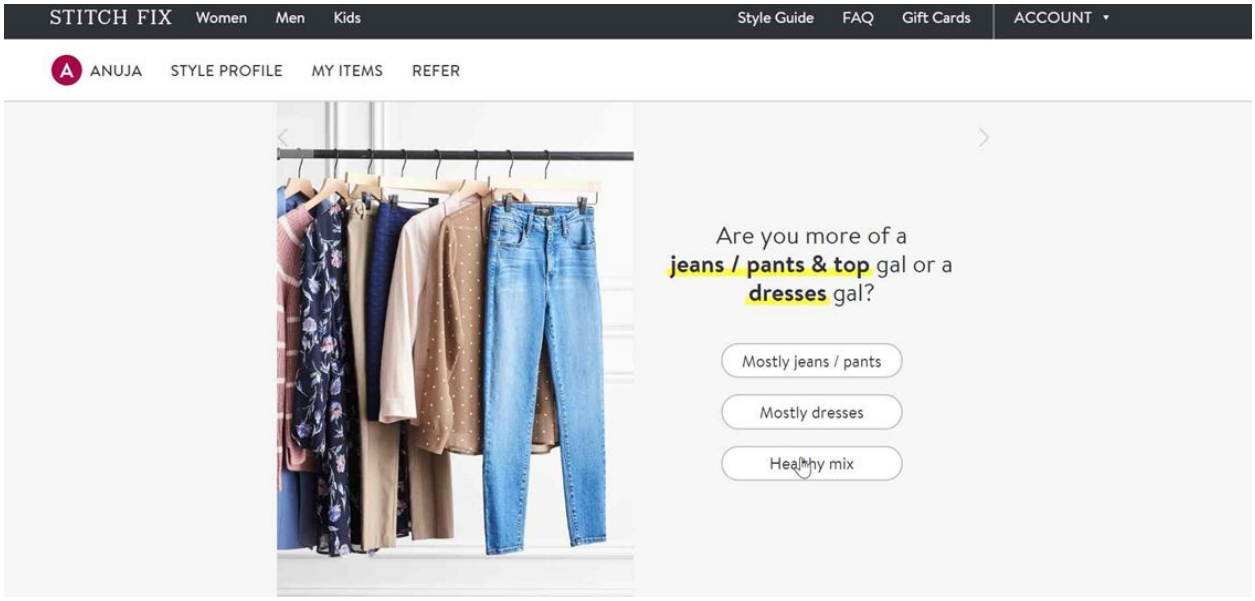
### StitchFix Survey:

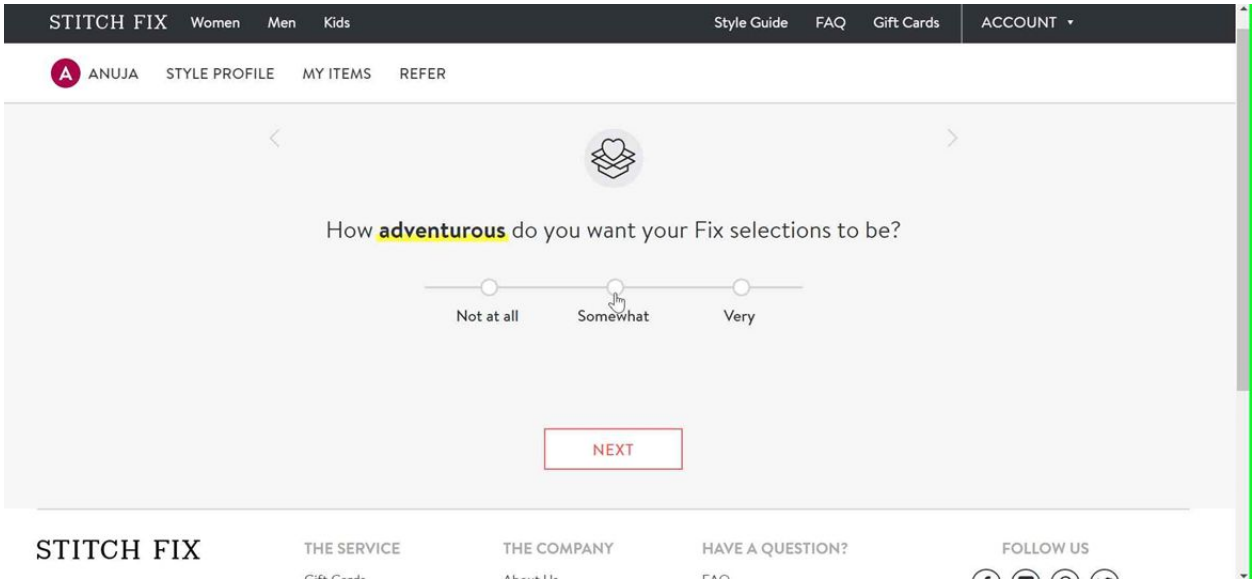


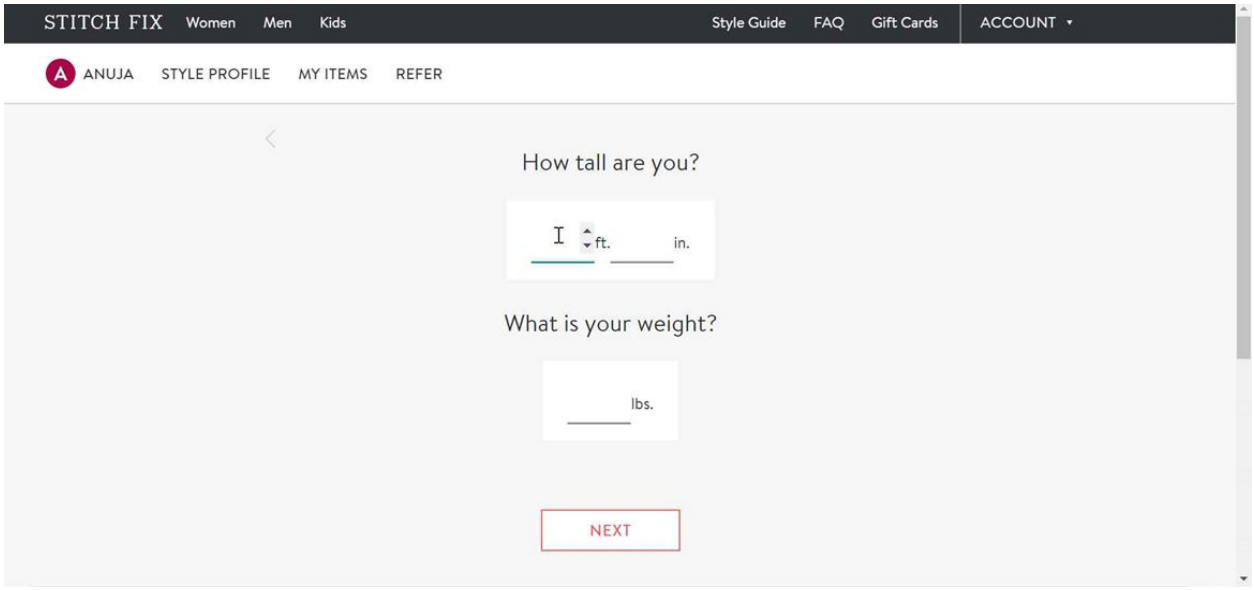

STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
Are you interested in premium brands?
We offer premium items from brands including Kate Spade, Theory, and Rebecca Minkoff.
Yes
No
NEXT
STITCH FIX
THE SERVICE
THE COMPANY
HAVE A QUESTION?
FOLLOW US
STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
We offer premium items from brands including Kate Spade, Theory, and Rebecca Minkoff.
Yes
No
Great -- From Which Categories?
JEWELRY
SHOES
DRESSES
JACKETS & COATS
TEES
SWEATERS / CARDIGANS
SHORTS
SHIRTS & BLOUSES
PANTS
JEANS
BAGS

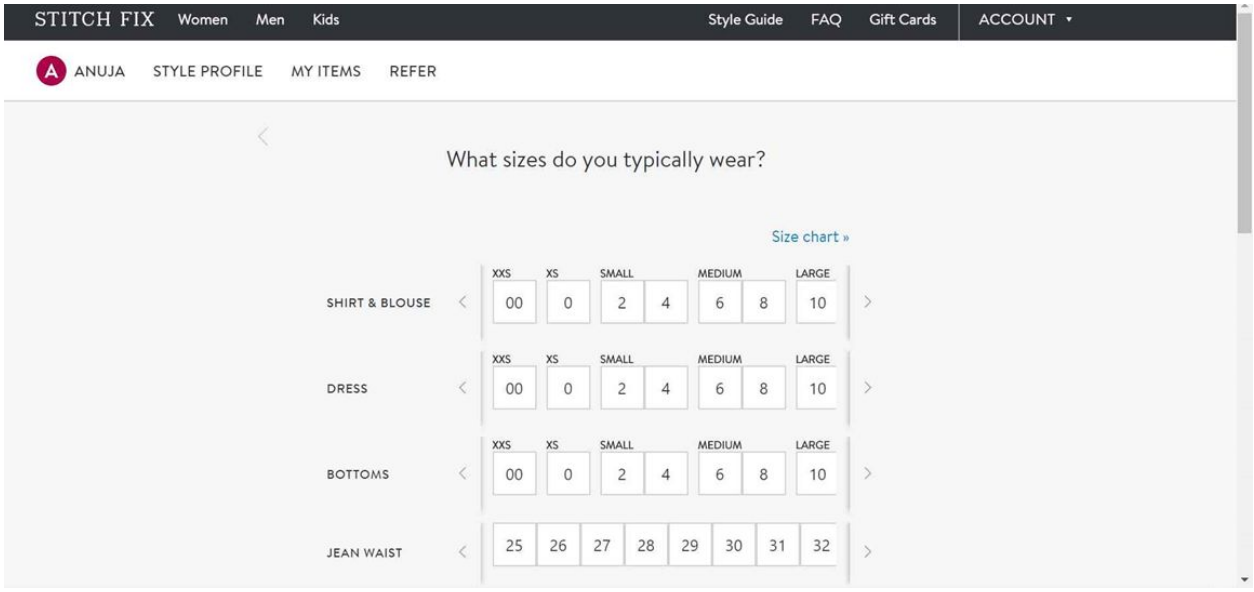

STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
What is your primary occupation?
Architecture / Engineering
Art / Design
Building / Maintenance
Business / Client Service
Community / Social Service
Computer / IT
Education
Entertainer / Performer
Farming / Fishing / Forestry

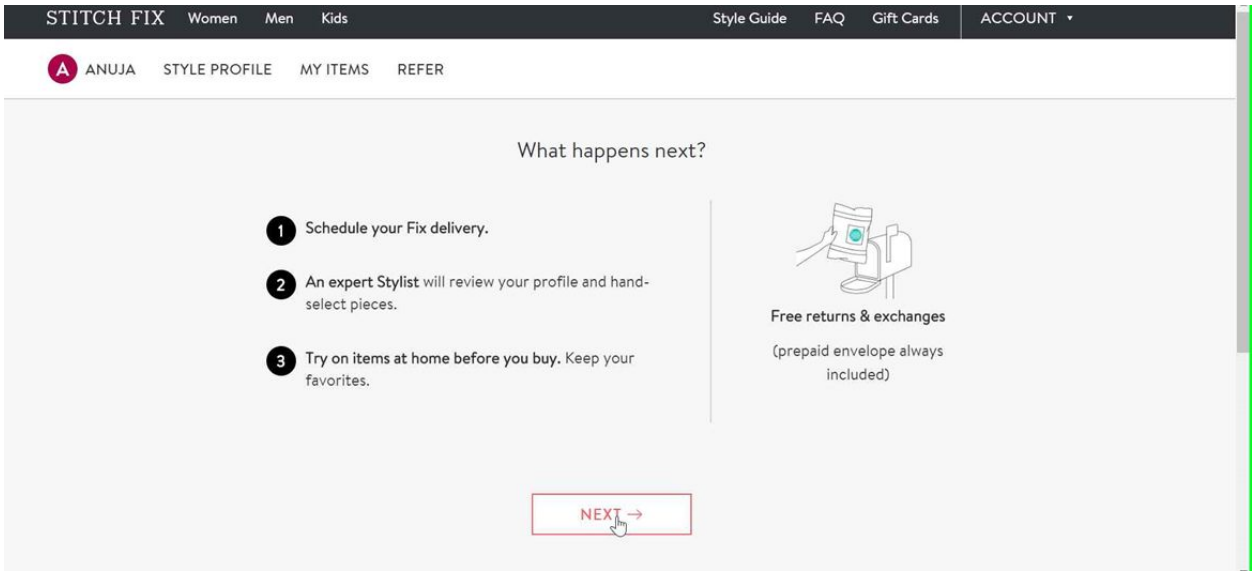

STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
Anything else we should know before we style you?
Example: My workplace is pretty casual. I can wear jeans but I would like to dress it up with cute tops! Also, please stick to warm tones - I look best in burgundy, plum and mustard. I prefer v-neck blouses and subtle prints.
500 characters remaining
NEXT →


STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
Are you more of a
jeans / pants & top gal or a
dresses gal?
Mostly jeans / pants
Mostly dresses
Healthy mix


STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
How adventurous do you want your Fix selections to be?
Not at all
Somewhat
Very
NEXT
STITCH FIX
THE SERVICE
THE COMPANY
HAVE A QUESTION?
FOLLOW US


STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
How tall are you?
ft.
in.
What is your weight?
lbs.
NEXT


STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
What sizes do you typically wear?
Size chart »
SHIRT & BLOUSE
DRESS
BOTTOMS
JEAN WAIST
XXS
XS
SMALL
MEDIUM
LARGE
00
0
2
4
6
8
10
25
26
27
28
29
30
31
32


STITCH FIX
Women
Men
Kids
Style Guide
FAQ
Gift Cards
ACCOUNT
ANUJA
STYLE PROFILE
MY ITEMS
REFER
What happens next?
1 Schedule your Fix delivery.
2 An expert Stylist will review your profile and hand-select pieces.
3 Try on items at home before you buy. Keep your favorites.
Free returns & exchanges
(prepaid envelope always included)
NEXT →

## Recommendation System Model:

We have designed a recommendation system to recommend products to customers based on their search.
Build a recommendation engine which suggests similar products to the given product in stitch fix.
This recommendation system works towards solving the problem of recommending the right products to the customers.

- In some ways, the problem is a classic collaborative filtering problem: given different clients' feedback on different styles, we must fill in the gaps in the (sparse) matrix to predict the result of sending a style to a client who has not yet received it
- As such, we do use some standard collaborative filtering algorithms (e.g. those who have liked what you have liked have also liked ...)
- However, unlike most collaborative filtering problems, we have a lot of explicit data, both from clients' self-descriptions and from clothing attributes. This helps with the cold start problem and also allows for greater accuracy if we employ algorithms that consider this data
- One such approach is mixed-effects modeling, which is particularly useful because of the longitudinal nature of our problem: it lets us learn (and track) our clients' preferences over time, both individually and as a whole
- And in addition to the many explicit features available, there are some particularly pertinent latent (unstated) features of both clients and styles that we can infer from other data (structured and/or unstructured) and use to improve our performance
- For example, a new client may tell us that she wears medium-sized blouses, but where exactly would her preference fall along the spectrum of smallish mediums to largish mediums? The same question also applies to particular styles of clothing in our inventory. (Note that in this illustration we're treating fit as unidimensional for simplicity, but in fact at Stitch Fix we treat it as multidimensional.)
- Natural language processing is used to score items based on the client's request note and textual feedback from other clients about the same item
- All of these algorithm scores—and many others like them—are taken into account when ordering and presenting options for the human expert stylist to consider

In [1]:
```
# import libraries
import boto3, re, sys, math, json, os, sagemaker, urllib.request
from sagemaker import get_execution_role
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from IPython.display import Image
from IPython.display import display
from time import gmtime, strftime
from sagemaker.predictor import csv_serializer

# Define IAM role
role = get_execution_role()
prefix = 'sagemaker/DEMO-xgboost-dm'
containers = {'us-west-2': '433757028032.dkr.ecr.us-west-2.amazonaws.com/xgboost:latest',
              'us-east-1': '811284229777.dkr.ecr.us-east-1.amazonaws.com/xgboost:latest',
              'us-east-2': '825641698319.dkr.ecr.us-east-2.amazonaws.com/xgboost:latest',
              'eu-west-1': '685385470294.dkr.ecr.eu-west-1.amazonaws.com/xgboost:latest'} # each region has its XGBoost
my_region = boto3.session.Session().region_name # set the region of the instance
print("Success - the MySageMakerInstance is in the " + my_region + " region. You will use the " + containers[my_region]
```

```
Success - the MySageMakerInstance is in the us-east-1 region. You will use the 811284229777.dkr.ecr.us-east-1.amazona
ws.com/xgboost:latest container for your SageMaker endpoint.
```

In [8]:
```
bucket_name = 'stitchfixteam' # <--- change this variable to a unique name for your bucket
s3 = boto3.resource('s3')
try:
    if  my_region == 'us-east-1':
      s3.create_bucket(Bucket=bucket_name)
    else:
      s3.create_bucket(Bucket=bucket_name, CreateBucketConfiguration={ 'LocationConstraint': my_region })
    print('S3 bucket created successfully')
except Exception as e:
    print('S3 error: ',e)
```

```
S3 bucket created successfully
```

## Implementation of Recommendation System:

In [39]:
```
print ('Number of data points : ', data.shape[0], \
       'Number of features:', data.shape[1])
data.head() # prints the top rows in the table.
```

```
Number of data points :  183138 Number of features: 7
```

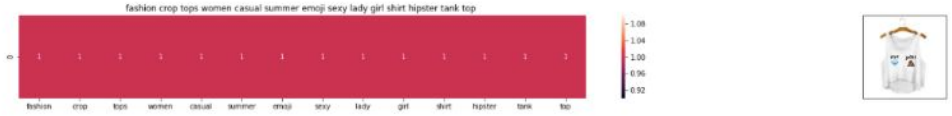
Out[39]:

| | asin | brand | color | medium_image_url | product_type_name | title | formatted_price |
|---|---|---|---|---|---|---|---|
| 0 | B016I2TS4W | FNC7C | None | https://images-na.ssl-images-amazon.com/images... | SHIRT | Minions Como Superheroes Ironman Long Sleeve R... | None |
| 1 | B01N49AI08 | FIG Clothing | None | https://images-na.ssl-images-amazon.com/images... | SHIRT | FIG Clothing Womens Izo Tunic | None |
| 2 | B01JDPCOHO | FIG Clothing | None | https://images-na.ssl-images-amazon.com/images... | SHIRT | FIG Clothing Womens Won Top | None |
| 3 | B01N19U5H5 | Focal18 | None | https://images-na.ssl-images-amazon.com/images... | SHIRT | Focal18 Sailor Collar Bubble Sleeve Blouse Shi... | None |
| 4 | B004GSI2OS | FeatherLite | Onyx Black/ Stone | https://images-na.ssl-images-amazon.com/images... | SHIRT | Featherlite Ladies' Long Sleeve Stain Resistan... | $26.26 |

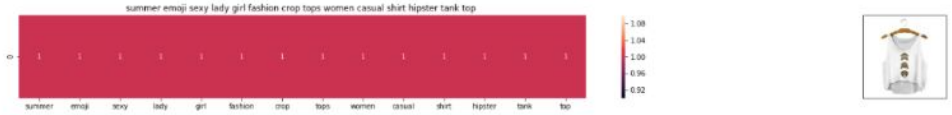
We brought down the number of data points from 183K to 28K

**These shirts are exactly same except in size (S, M,L,XL)**

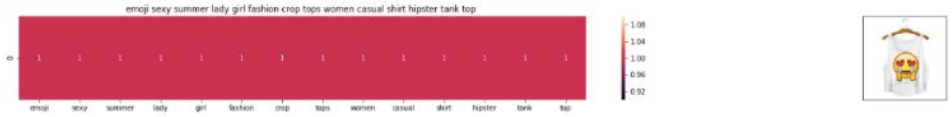
# 11. Text based product similarity




```
ASIN : B010V3B44G
Brand: Doxi Supermall
Title: fashion crop tops women casual summer emoji sexy lady girl shirt hipster tank top
Euclidean similarity with the query image : 0.0
============================================================
```

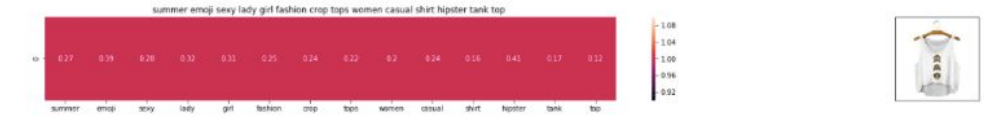



```
ASIN : B010V3BDII
Brand: Doxi Supermall
Title: summer emoji sexy lady girl fashion crop tops women casual shirt hipster tank top
Euclidean similarity with the query image : 0.0
============================================================
```

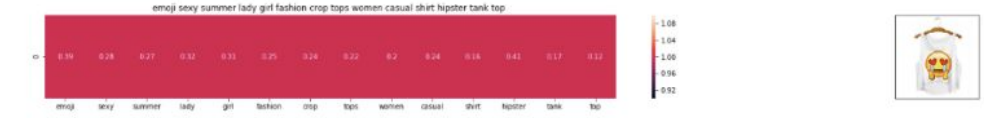



```
ASIN : B010V3BLWQ
Brand: Doxi Supermall
Title: emoji sexy summer lady girl fashion crop tops women casual shirt hipster tank top
Euclidean similarity with the query image : 0.0
```

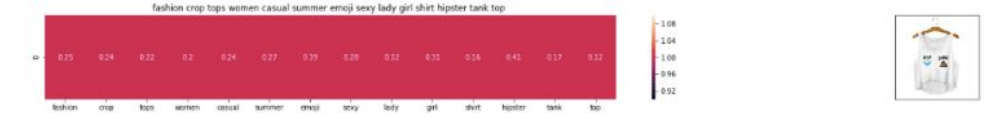
# 12. TF-IDF based product similarity




```
ASIN : B010V3BDII
BRAND : Doxi Supermall
Eucliden distance from the given image : 0.0
============================================================================================================================
========
```

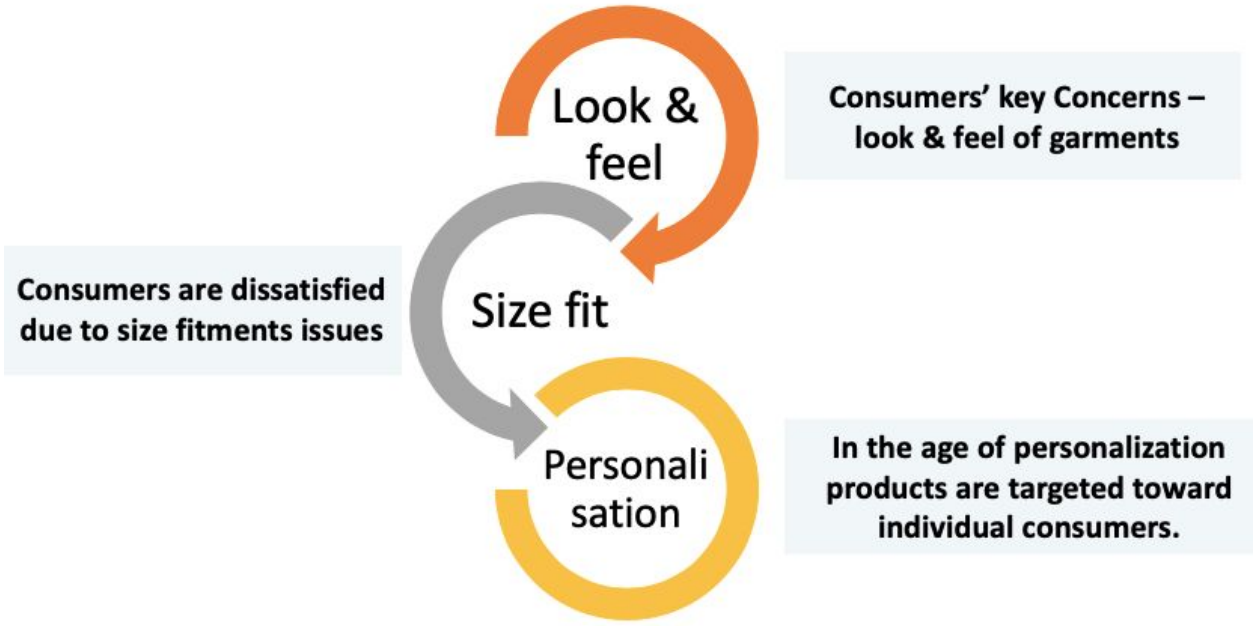



```
ASIN : B010V3BLWQ
BRAND : Doxi Supermall
Eucliden distance from the given image : 0.0
============================================================================================================================
========
```

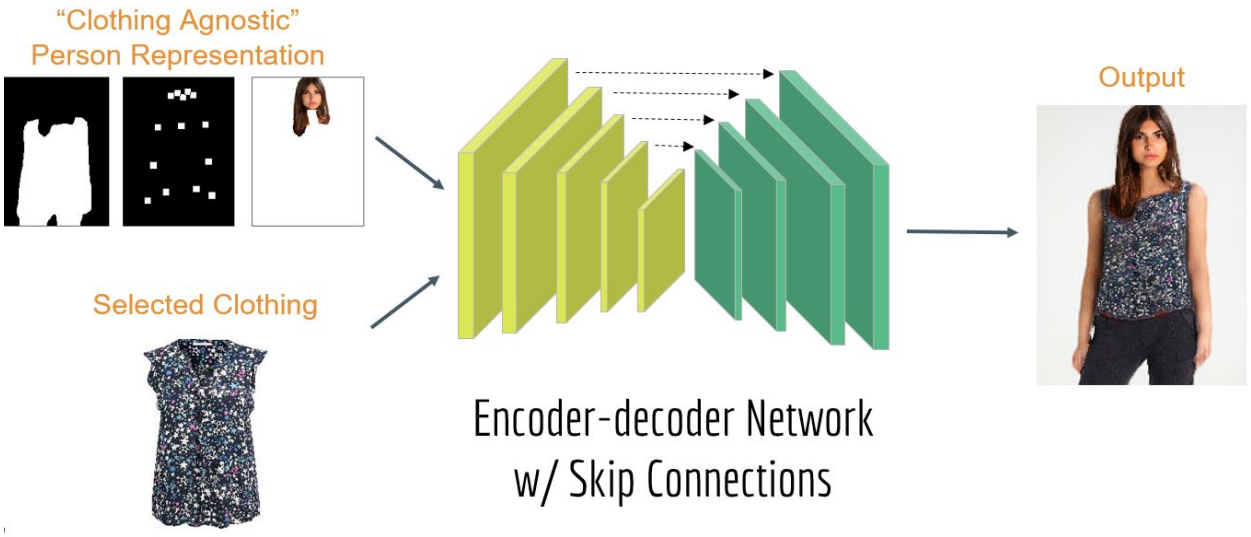



```
ASIN : B010V3B44G
BRAND : Doxi Supermall
Eucliden distance from the given image : 0.0
============================================================================================================================
--------
```

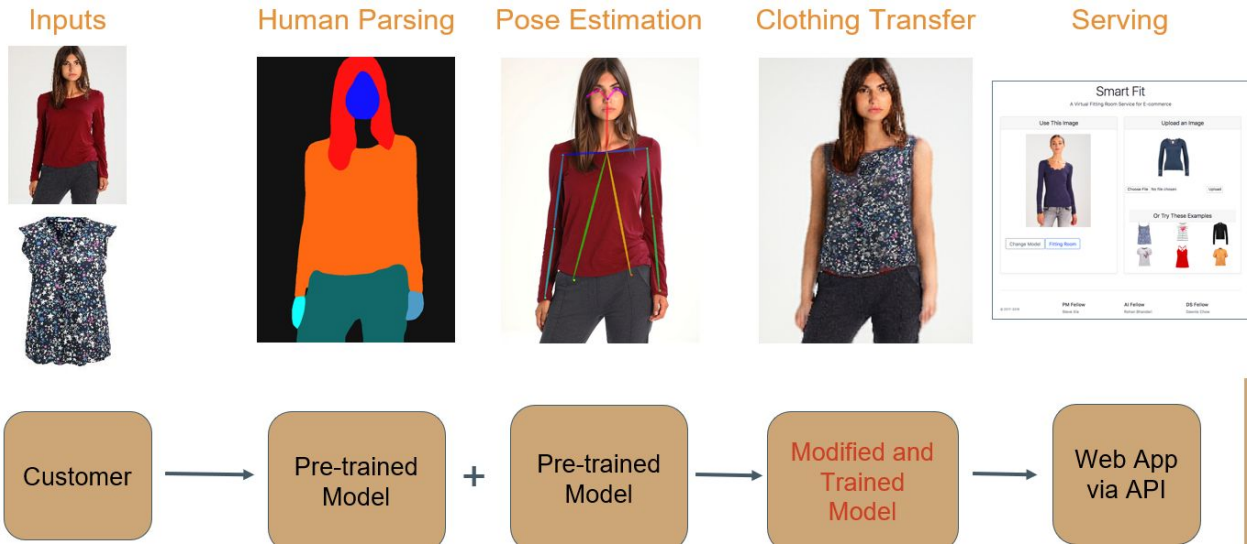
## Virtual Wardrobe:




# Clothing Transfer



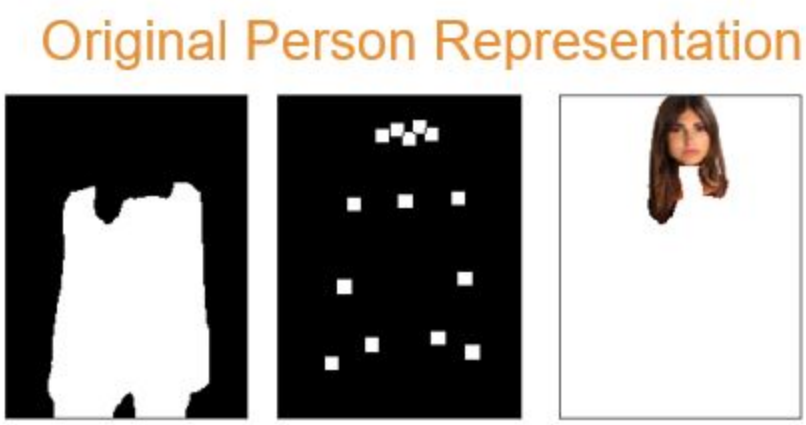

**Pipeline:**



**Process Outline:**

## Stage 1:

End points of the picture provided are detected and created for object detection so as to make the masking of the picture of the piece of cloth onto the picture easier.




## Stage 2:

Here, outfit image masked on the picture is checked for the even skin tone and masking the outfit perfectly on the picture.

The input and output skin colour are plotted and the midpoint is considered as final skintone.

1. The result image of stage 1

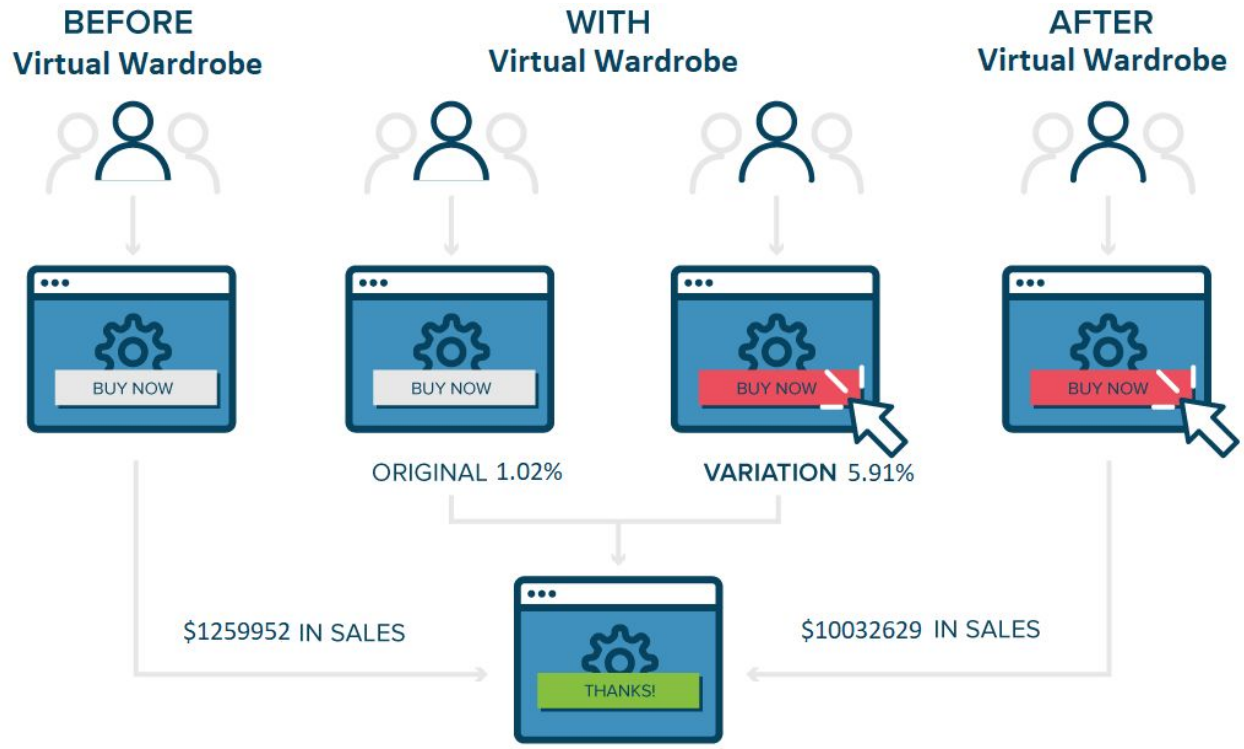
2. The outfit is then tilted according the pose in the picture

3. The points obtained from stage 1

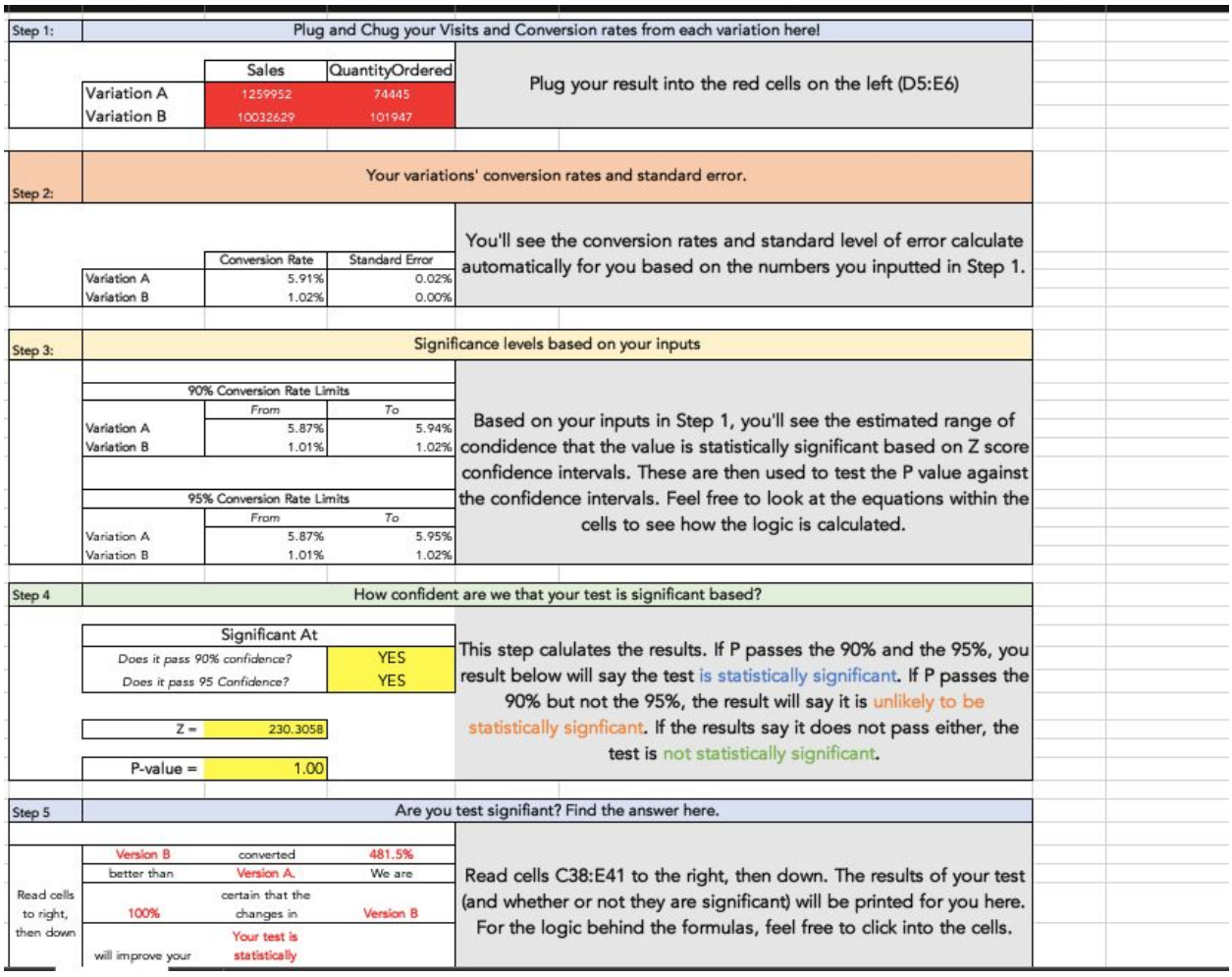
4. The outfit is masked to the points generated

5. This is the final product after masking the outfit and the image

# AB Testing:




| Status | Test | Start | End | Prediction | Result | Statistically Significant? | Notes | Next Steps |
|---|---|---|---|---|---|---|---|---|
| Completed | Survey form on signup | 7/17/19 | 8/5/19 | Version B will perform better because the original version is time consuming | Success | ✓ | Variation B performed 8% better than the original version and was statistically significant at 95% confidence. Declared version B the winner | Chose Variation B as winner, setting up a/b on next event |
| Not Started | Recommendation plus Virtual Wardrobe | 8/27/17 | 9/20/17 | Version B (image with background) will perform better | Inconclusive | X | | |
| Not Started | Different Headline. A is the title, B is descriptive | 8/28/17 | 9/21/17 | Version A will perform better because it matches promo copy | Inconclusive | X | | |
| In Progress | New vs. Old landing page layout template | 8/12/19 | 8/15/19 | Version A (new template) will perform better because the layout is cleaner and more modern | Failure | ✓ | Verion B (the old LP template) performed 6% better than A | Chose Variation B as winner, setting up a/b on next event |
| Completed | Virtual Wardrobe | 8/10/19 | 8/16/17 | Version b will perform better | Success | ✓ | Variation B performed 21% better than the original version, 100% sure version be will improve conversions. Statistically significant. | Chose Variation B as winner, setting up a/b on copy next |



| Step 1: | Plug and Chug your Visits and Conversion rates from each variation here! | | |
|---|---|---|---|
| | | Sales | QuantityOrdered |
| | Variation A | 1259952 | 74445 |
| | Variation B | 10032629 | 101947 |

Plug your result into the red cells on the left (D5:E6)

| Step 2: | Your variations' conversion rates and standard error. | |
|---|---|---|
| | Conversion Rate | Standard Error |
| Variation A | 5.91% | 0.02% |
| Variation B | 1.02% | 0.00% |

You'll see the conversion rates and standard level of error calculate automatically for you based on the numbers you inputted in Step 1.

| Step 3: | Significance levels based on your inputs | |
|---|---|---|
| 90% Conversion Rate Limits | | |
| | *From* | *To* |
| Variation A | 5.87% | 5.94% |
| Variation B | 1.01% | 1.02% |
| 95% Conversion Rate Limits | | |
| | *From* | *To* |
| Variation A | 5.87% | 5.95% |
| Variation B | 1.01% | 1.02% |

Based on your inputs in Step 1, you'll see the estimated range of condidence that the value is statistically significant based on Z score confidence intervals. These are then used to test the P value against the confidence intervals. Feel free to look at the equations within the cells to see how the logic is calculated.

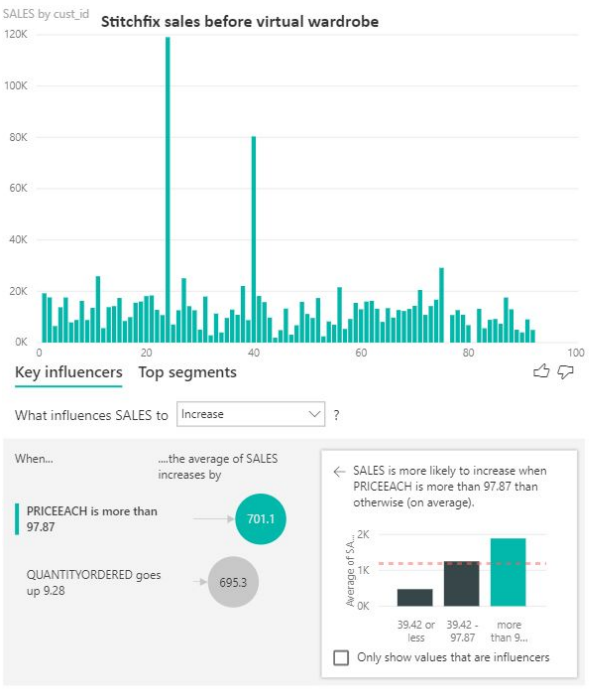
| Step 4 | How confident are we that your test is significant based? | |
|---|---|---|
| Significant At | | |
| *Does it pass 90% confidence?* | YES | |
| *Does it pass 95 Confidence?* | YES | |
| Z = | 230.3058 | |
| P-value = | 1.00 | |

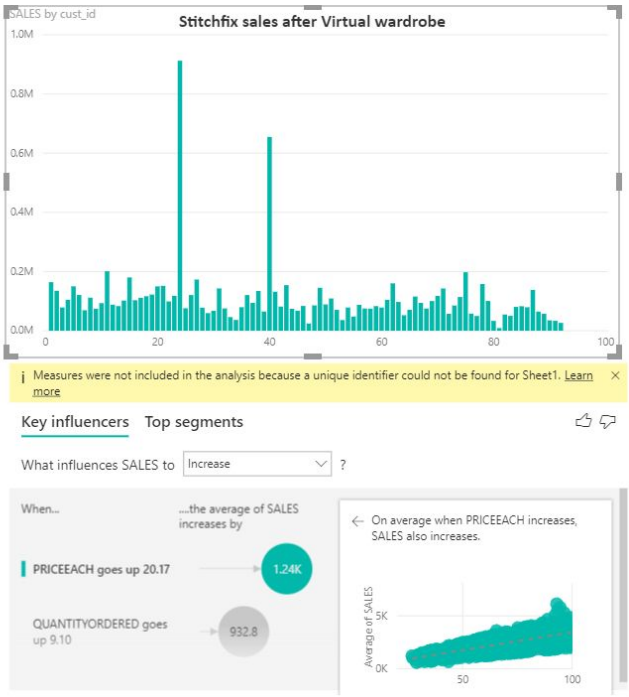
This step calulates the results. If P passes the 90% and the 95%, you result below will say the test is statistically significant. If P passes the 90% but not the 95%, the result will say it is unlikely to be statistically signficant. If the results say it does not pass either, the test is not statistically significant.

| Step 5 | Are you test signifiant? Find the answer here. | | |
|---|---|---|---|
| | Version B | converted | 481.5% |
| | better than | Version A. | We are |
| Read cells to right, then down | 100% | certain that the changes in | Version B |
| | will improve your | Your test is statistically | |

Read cells C38:E41 to the right, then down. The results of your test (and whether or not they are significant) will be printed for you here. For the logic behind the formulas, feel free to click into the cells.

# Dashboard:

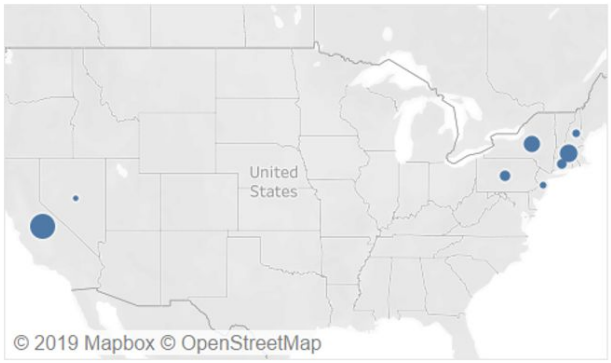

SALES by cust_id
Stitchfix sales before virtual wardrobe
120K
100K
80K
60K
40K
20K
0K
0
20
40
60
80
100
Key influencers
Top segments
What influences SALES to
Increase
?
When...
....the average of SALES increases by
PRICEEACH is more than 97.87
701.1
QUANTITYORDERED goes up 9.28
695.3
SALES is more likely to increase when PRICEEACH is more than 97.87 than otherwise (on average).
Average of SA...
2K
1K
0K
39.42 or less
39.42 - 97.87
more than 9...
Only show values that are influencers


SALES by cust_id
Stitchfix sales after Virtual wardrobe
1.0M
0.8M
0.6M
0.4M
0.2M
0.0M
0
20
40
60
80
100
Measures were not included in the analysis because a unique identifier could not be found for Sheet1. Learn more
Key influencers
Top segments
What influences SALES to
Increase
?
When...
....the average of SALES increases by
PRICEEACH goes up 20.17
1.24K
QUANTITYORDERED goes up 9.10
932.8
On average when PRICEEACH increases, SALES also increases.
Average of SALES
5K
0K
50
100

## Sales per state (Before virtual wardrobe)


| State | |
|---|---|
| Null | 665,514 |
| BC | 11,975 |
| CA | 189,862 |
| CT | 28,769 |
| Isle of Wight | 12,972 |
| MA | 94,943 |
| NH | 18,155 |
| NJ | 13,778 |
| NSW | 28,082 |
| NV | 9,160 |
| NY | 81,591 |
| Osaka | 4,840 |
| PA | 34,246 |
| Quebec | 1,887 |

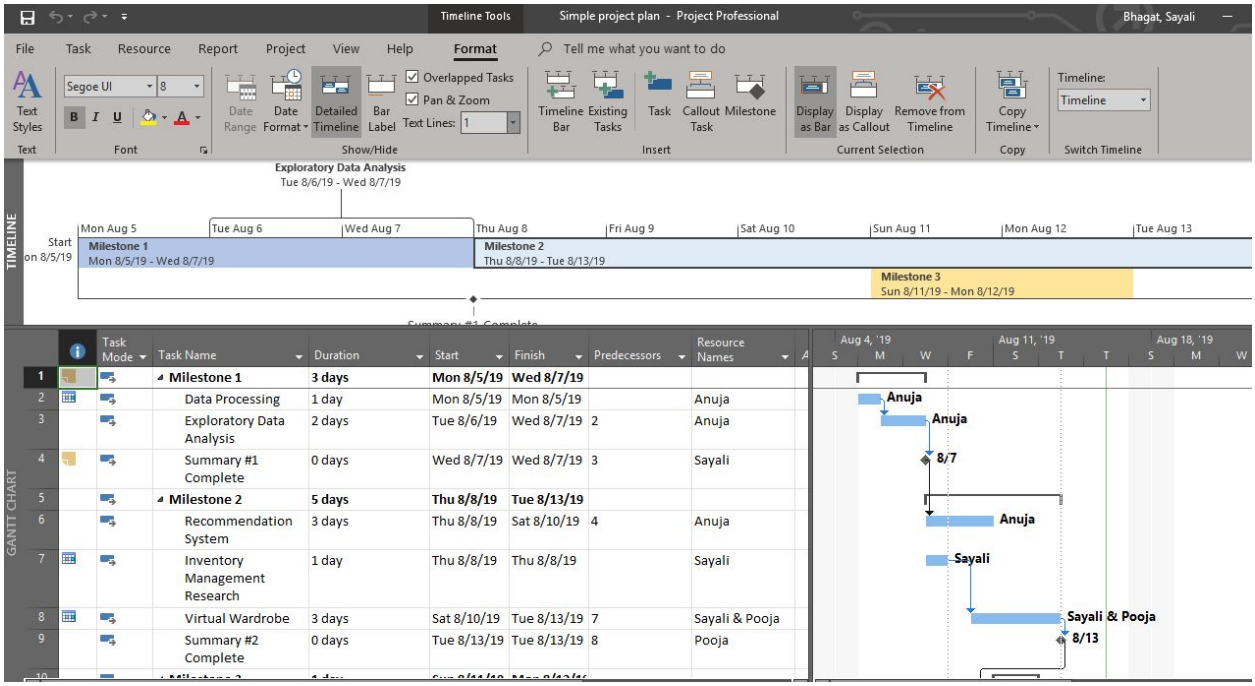
## Sales per state (After virtual wardrobe)




| State | |
|---|---|
| Null | 5,104,346 |
| BC | 149,874 |
| CA | 1,555,218 |
| CT | 255,985 |
| Isle of Wight | 78,241 |
| MA | 708,565 |
| NH | 131,685 |
| NJ | 83,228 |
| NSW | 331,624 |
| NV | 82,751 |
| NY | 660,732 |
| Osaka | 67,605 |
| PA | 280,618 |
| Quebec | 86,206 |

# Milestones:

We'll be using MS project app for tracking the task and progress of the project. In this way will be learning a project management tool as well




| | Task Mode | Task Name | Duration | Start | Finish | Predecessors | Resource Names |
|---|---|---|---|---|---|---|---|
| 1 | | **Milestone 1** | **3 days** | **Mon 8/5/19** | **Wed 8/7/19** | | |
| 2 | | Data Processing | 1 day | Mon 8/5/19 | Mon 8/5/19 | | Anuja |
| 3 | | Exploratory Data Analysis | 2 days | Tue 8/6/19 | Wed 8/7/19 | 2 | Anuja |
| 4 | | Summary #1 Complete | 0 days | Wed 8/7/19 | Wed 8/7/19 | 3 | Sayali |
| 5 | | **Milestone 2** | **5 days** | **Thu 8/8/19** | **Tue 8/13/19** | | |
| 6 | | Recommendation System | 3 days | Thu 8/8/19 | Sat 8/10/19 | 4 | Anuja |
| 7 | | Inventory Management Research | 1 day | Thu 8/8/19 | Thu 8/8/19 | | Sayali |
| 8 | | Virtual Wardrobe | 3 days | Sat 8/10/19 | Tue 8/13/19 | 7 | Sayali & Pooja |
| 9 | | Summary #2 Complete | 0 days | Tue 8/13/19 | Tue 8/13/19 | 8 | Pooja |

# Deployment Details:

1) Language: Python
2) Cloud Tools/Platforms: Amazon Web Services
3) Tools for Analysis: Tableau, Power BI, Salesforce
4) Other Considerations: Google Cloud Platform, Heroku

5) Team Viewer, MS Project

# References and Sources:

This project builds from the work listed below:

- Human parsing
    - LIP_JPPNet (repo, paper)
- Pose estimation
    - Realtime Multi-Person Pose Estimation (repo, paper)
        - Keras implementation
- Virtual try-on
    - VITON (repo, paper)

- http://jonathansoma.com/lede/foundations/classes/text%20processing/tf-idf/