Cross Stitch Fun

Making a Cross Stitch Pattern with K-Means Clustering

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Objective

The objective is to demonstrate how create a cross stitch pattern from an image and select an appropriate amount of colors for the pattern.

Introduction

Cross stitch is a fun hobby where images are recreated stitch by stitch on fabric. Obviously, it is impossible to recreate the exact image, but k-means clustering can help identify the main colors in the image to best approximate it. Four functions are presented here to help the user select the best number of colors to use and to create a pattern using DMC thread colors that is customizable for their cross-stitching needs.

Example

To demonstrate, let's make a pattern of Harry Styles' face. Here is the picture we want to cross-stitch:

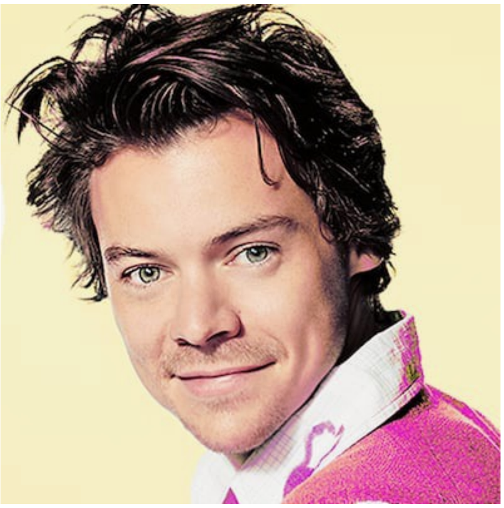


Figure 1: Original image of Harry Styles

These are the packages that we will use to run the functions:

```
library(imager)
library(tidyverse)
library(tidymodels)
library(sp)
library(scales)
library(cowplot)
library(dmc)
```

Step 1: Processing the Image

The first function is `process_image`. Images have to be processed and prepared before they can be used by other functions. `process_image` takes two inputs:

- `image_file_name`: the name/file path of the image you want to cross-stitch
- `k_list`: a list of the possible number of colors you are considering

In the picture of Harry, I can see 5 main colors: pink and white shirt, yellow background, skin color, and brown hair. But, his eyes are also green and there are many darker shades in his hair as well. So, I am going to consider including between 5 and 8 colors in my final cross stitch. The subsequent functions will help me decide on a final number of colors.

We want to save the output as `cluster_info`.

```
cluster_info <- process_image("HarryStyles.jpeg", c(5, 6, 7, 8))
# k_list should be inputted as a vector
```

At this point, it is possible to get some warnings. This usually means that the values of k are too high and the algorithm is having trouble separating the colors in the image into distinct clusters. The maximum iterations is set to 30, so it may be the case that the algorithm was unable to converge during these 30 iterations. For this reason, clusterings are computed 20 times for each value of k, so that the best result can be used.

`cluster_info` returns a list of two elements. The first element is a data frame of the image, with columns x and y describing the position and R, G, B describing the color of each pixel.

```
head(cluster_info[[1]])
```

```
##   x y         R         G         B
## 1 1 1 0.9647059 0.9333333 0.7411765
## 2 2 1 0.9647059 0.9333333 0.7411765
## 3 3 1 0.9647059 0.9333333 0.7411765
## 4 4 1 0.9647059 0.9333333 0.7411765
## 5 5 1 0.9647059 0.9333333 0.7411765
## 6 6 1 0.9647059 0.9333333 0.7411765
```

The second element of `cluster_info` is a nested tibble that contains the information about the clusterings for each value of k. The `glanced` and `tidied` columns contain tibbles that are summaries of the k-means results, with information like the variance within clusters and the closest DMC thread to each cluster color.

```
cluster_info[[2]]
```

```
## # A tibble: 4 x 4
##       k kclust   glanced          tidied
##   <dbl> <list>   <list>           <list>
## 1     5 <kmeans> <tibble [1 x 4]> <tibble [5 x 9]>
## 2     6 <kmeans> <tibble [1 x 4]> <tibble [6 x 9]>
## 3     7 <kmeans> <tibble [1 x 4]> <tibble [7 x 9]>
## 4     8 <kmeans> <tibble [1 x 4]> <tibble [8 x 9]>
```

```
head(cluster_info[[2]] %>% pluck("glanced", 3))
```

```
## # A tibble: 1 x 4
##    totss tot.withinss betweenss  iter
##    <dbl>        <dbl>     <dbl> <int>
## 1 47494.        1122.    46371.     4
```

```
head(cluster_info[[2]] %>% pluck("tidied", 3))
```

```
## # A tibble: 6 x 9
##        R      G      B  size withinss cluster colours dmc_cols dmc_names
##    <dbl>  <dbl>  <dbl> <int>    <dbl> <fct>   <chr>   <chr>    <chr>
## 1 0.957  0.929  0.781  72011     237. 1       #F4EDC7 #F5ECCB  Old Gold - Very ~
## 2 0.280  0.210  0.203   9486     116. 2       #473634 #4B3C2A  Mocha Brown - Ve~
## 3 0.903  0.740  0.657  24494     184. 3       #E6BDA8 #EBB7AF  Shell Pink - Ver~
## 4 0.860  0.319  0.623   8465     172. 4       #DB519F #C54989  Plum - Light (36~
## 5 0.0600 0.0391 0.0357 22732     108. 5       #0F0A09 #1E1108  Black Brown (337~
## 6 0.776  0.563  0.523  12975     157. 6       #C69085 #BA8B7C  Rosewood - Light~
```

Step 2: Choosing Colors

Now that we have all of this information, we can figure out how many colors we should include. There are two functions to help us do this.

The first is scree_plot (Figure 2), which takes cluster info and graphs a plot with the number of clusters on the x-axis and the total within group sum of squares for each clustering on the y-axis, which is basically a measure of how similar the colors within each clustering are. When there are large dips, like between 5 and 6 clusters, it means that the colors in each of the 6 clusters are a lot more similar than the colors in the 5 clusters, so it is a better grouping. From 7 to 8 clusters, the drop off is not as significant, but is still a difference of 1000, so 8 clusters may be better.

```
scree_plot(cluster_info)
```

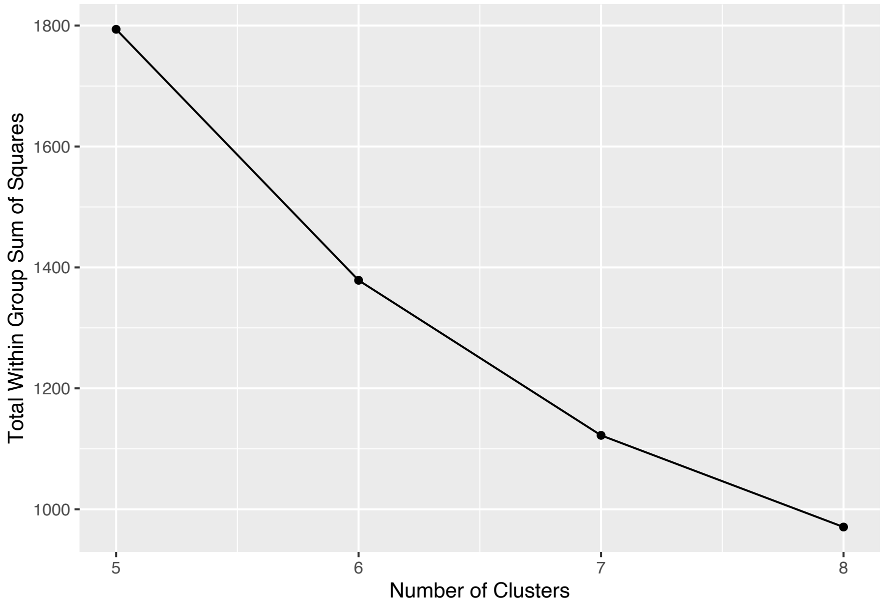
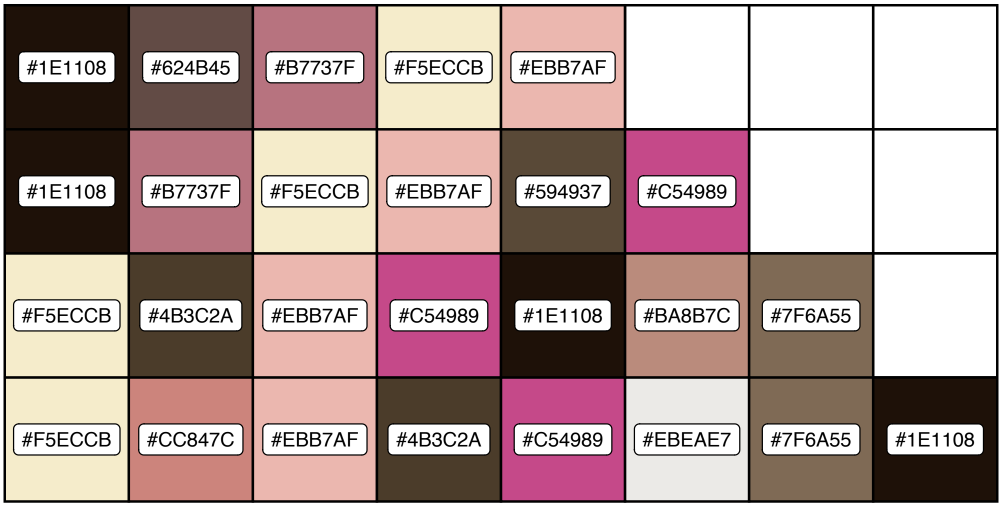


Figure 2: Scree Plot

To further investigate this, we can look at the actual colors of each clustering (Figure 3).

```
color_strips(cluster_info)
```



#1E1108	#624B45	#B7737F	#F5ECCB	#EBB7AF			
#1E1108	#B7737F	#F5ECCB	#EBB7AF	#594937	#C54989		
#F5ECCB	#4B3C2A	#EBB7AF	#C54989	#1E1108	#BA8B7C	#7F6A55	
#F5ECCB	#CC847C	#EBB7AF	#4B3C2A	#C54989	#EBEAE7	#7F6A55	#1E1108

Figure 3: Color Strips for Each Clustering

We can see that when k=8, we get an off-white color that we did not get with any of the previous clusterings. Since we want Harry to have a nice white collar, our preferred number of clusters is k=8.

Step 3: Making the Pattern!

Now that we've decided on the number of colors, we can make the pattern using the `make_pattern` function, which allows for several customizations to the pattern:

- `k` - the number of colors
- `x_size` - how many stitches you want in the x-direction of the pattern; the y-direction will be proportionately calculated
- `black_white` - option to make the pattern in black and white; default is FALSE
- `background_color` - option to specify a background color from the pattern; default is NULL

In Figure 4, we make a pattern with 8 colors that is 40 stitches across with the default settings (all colors included in the pattern and colors are shown).

```
make_pattern(cluster_info, k = 8, x_size = 40)
```

We can also customize our pattern in a number of ways. First, we can make it black and white. This can be helpful for the lighter colors that are hard to see or if you want to print in black and white (Figure 5). To do so, set `black_white = TRUE`.

```
make_pattern(cluster_info, k = 8, x_size = 40, black_white = TRUE)
```

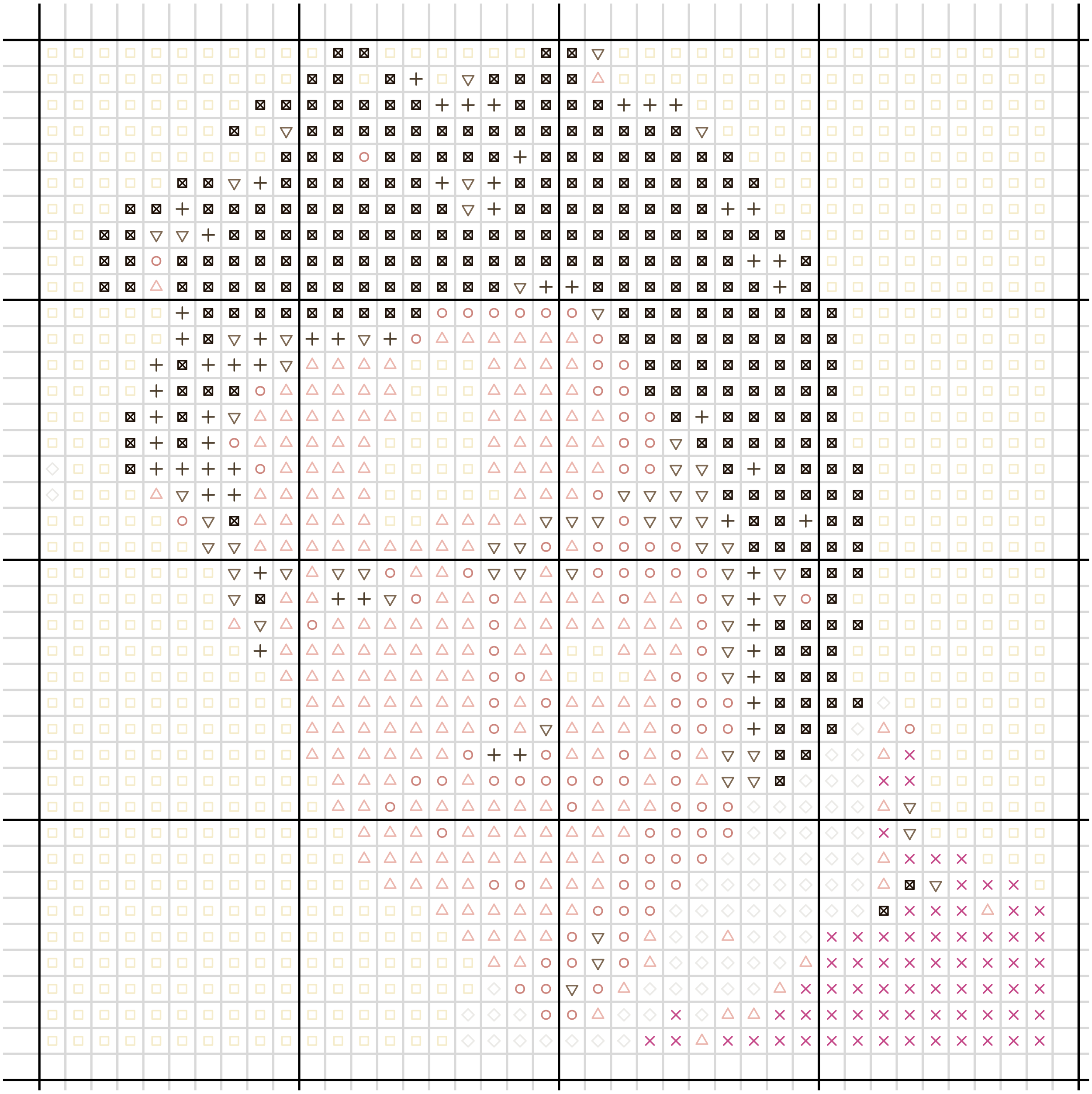
If we didn't want this yellow background in the pattern, it can be removed (Figure 6). We can simply refer back to the output of `color_strips` to identify the hex code of the color (should be in the form #FFFFFF) to tell the function to omit it through the `background_color` argument.

```
make_pattern(cluster_info, k = 8, x_size = 40, background_color = "#F5ECCB")
```

A word of caution on this: Sometimes the background color is used in the actual image. In this case, we can see that Harry is missing some of his forehead because they were closer to that yellow color than the rest of his skin. So we would have to be mindful of this and adjust the pattern ourselves when using it.

Notes

Sometimes the pattern may have less colors than what was specified. This is because the resolution of the image is reduced in order to make the pattern, so insignificant colors may be lost in this process.



DMC Thread Color

□ Old Gold - Very Light (677)

○ Shell Pink - Light (223)

△ Shell Pink - Very Light (224)

+ Mocha Brown - Very Dark (3031)

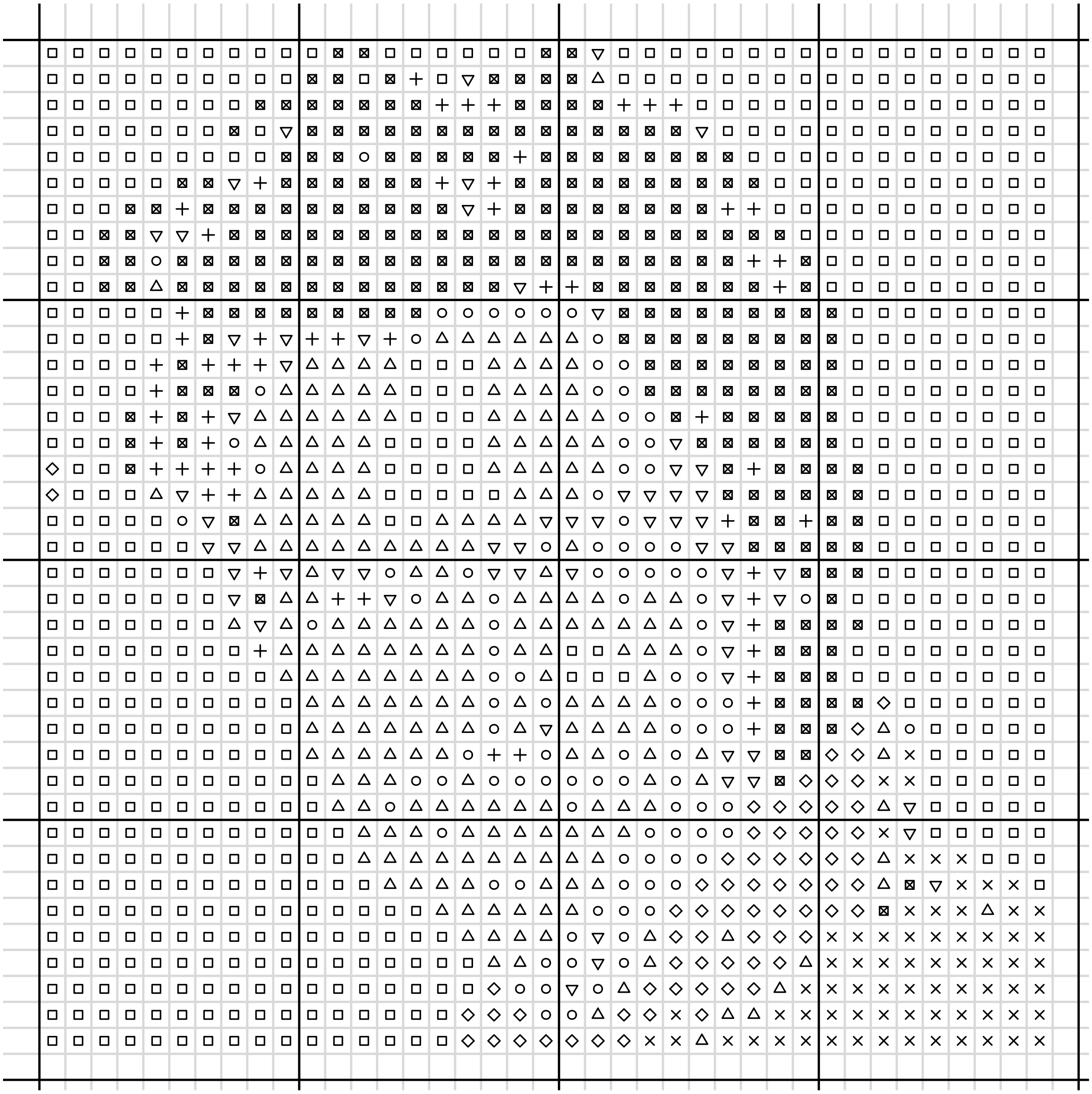
× Plum - Light (3607)

◇ Brown Gray - Very Light (3024)

▽ Beige Gray - Ultra Dark (3790)

⊠ Black Brown (3371)

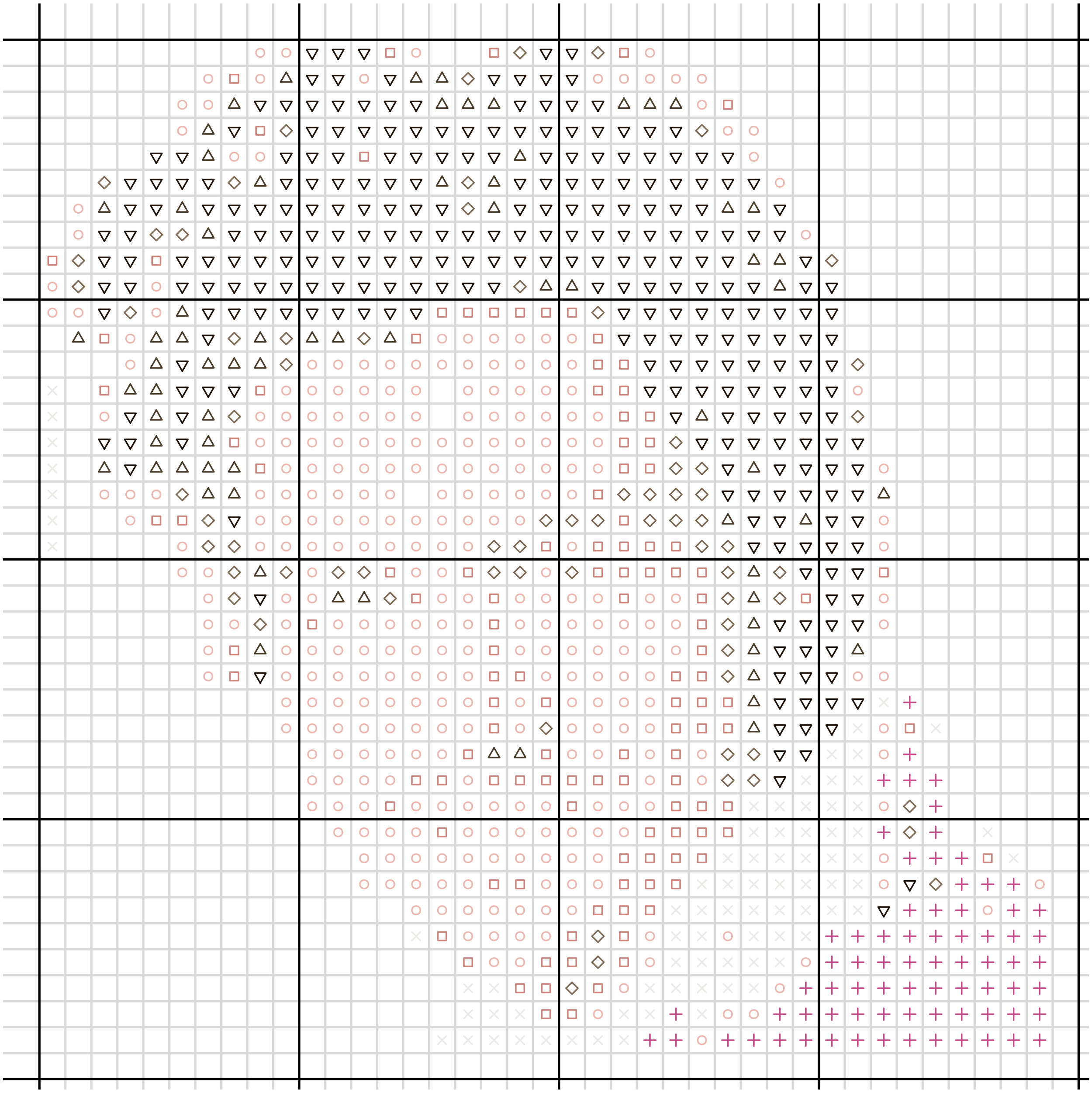
Figure 4: Default pattern



DMC Thread Color

□	Old Gold - Very Light (677)
○	Shell Pink - Light (223)
△	Shell Pink - Very Light (224)
+	Mocha Brown - Very Dark (3031)
×	Plum - Light (3607)
◇	Brown Gray - Very Light (3024)
▽	Beige Gray - Ultra Dark (3790)
⊠	Black Brown (3371)

Figure 5: Black and white pattern



DMC Thread Color

□	Shell Pink - Light (223)
○	Shell Pink - Very Light (224)
△	Mocha Brown - Very Dark (3031)
+	Plum - Light (3607)
×	Brown Gray - Very Light (3024)
◇	Beige Gray - Ultra Dark (3790)
▽	Black Brown (3371)

Figure 6: Without background color