COMP5900C
Assignment 1
Low-Level Texture Synthesis

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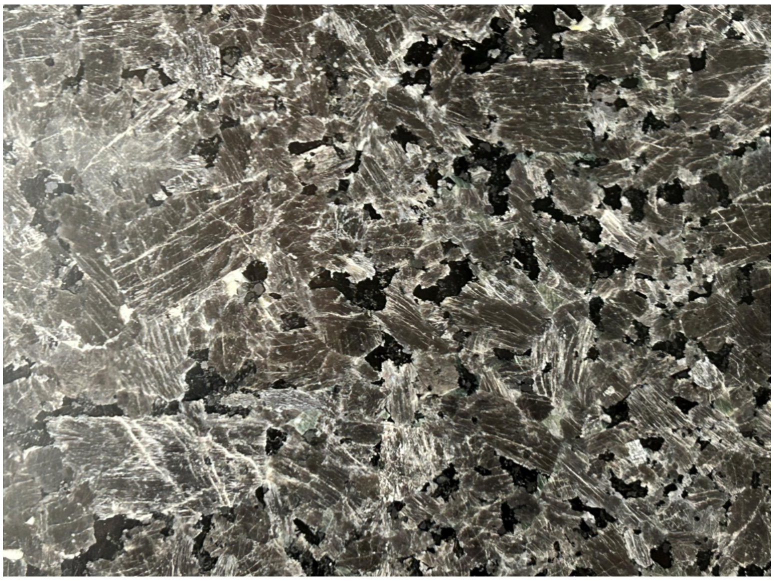
1 Target

The goal of this report is to synthesize a texture similar to the following



using low-level image processing operations in combination with parametric noise. This granite-like texture is particularly interesting from a pure structural synthesis point of view at it has depends very little on color and relies on strong contrast and clear sharp lines to define both high and low frequency features.

The synthesis approach described was inspired by both the properties of real-world granite counter top materials and the natural intuition to segment textures into repeating or layered shapes. The texture generation procedure is based on generating granite "shards" at various scales and layering to create the illusion of depth.

The silhouette of a single granite shard is composed of a more or less convex polygon with jagged edges, textured with various frequencies of straight bright cracks that are generally anisotropic over a single shard. At this resolution, the background beneath the shards seems to be composed of a dark and relatively continuous noise with small specular pieces embedded within it.

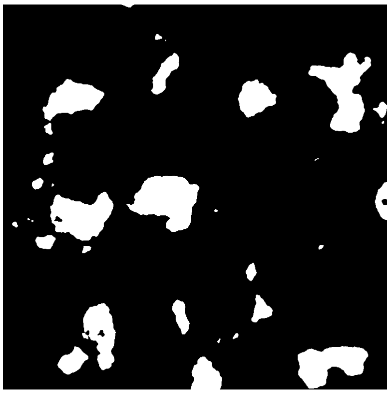
Therefore, the high-level strategy followed for creating similar textures was:

1. Generate shard shapes
2. Texture shard interiors
3. Layer shards overtop one another
4. Fill empty regions with background

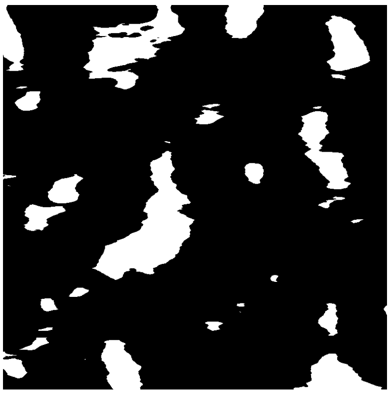
2 Approach

2.1 Shard Generation

To generate the shards, I knew that a thresholded noise function generally created isolated splats that reliably appeared as random polygon silhouettes. As the noise basis for this implementation, simplex noise was used to an excellent open source implementation being available for Processing/Java. Combining several octaves of base simplex noise with a relatively high threshold yielded the following initial shard polygons.



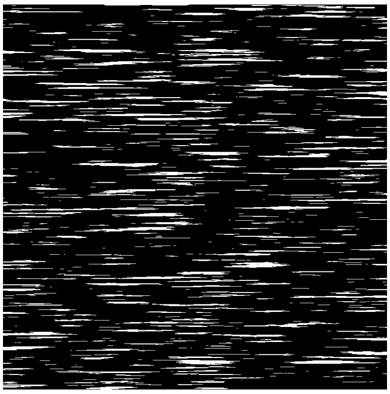
Reexamining the sample texture provided, the shards seem to have more jagged edges, generally along some lateral axis assuming the shards were rotated. To obtain this edge behaviour, a parameter was added to the noise to allow for higher octaves to be stretched in the x direction. On top of this, the noise function was globally biased towards the x direction, to further compress the variation in the shard edges along the y axis. This was effective in adding sharper features and more interested silhouettes.



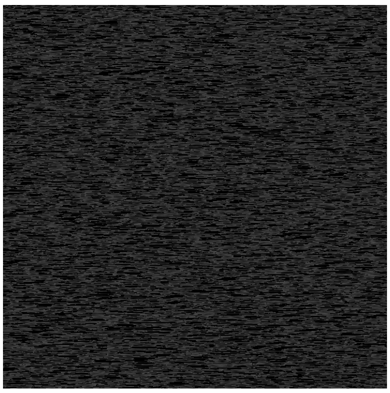
2.2 Shard Texturing

At a high level, the provided sample shows a few kinds of local texture applied to each shard. Large cracks travel across the shards again in their local lateral directions, aligned with smaller crack-like details aligned in their general direction. Finally a few small imperfections seem to travel relatively perpendicular to the main crack directions.

To generate the large crack texture, the same noise function was used with an extreme bias towards sampling large intervals in the y coordinate, resulting in the noise appearing compressed along the height of the image. Also the inverted absolute value of the noise function was taken to further create sharp peaks.

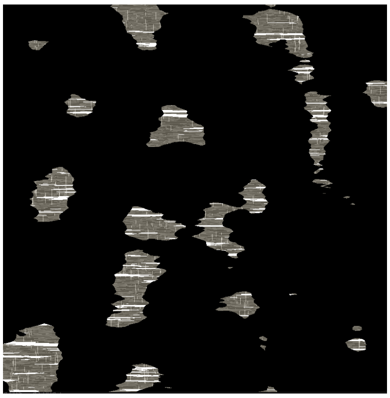


A similar process was used to create the fine surface cracks. The parameters were tuned to increase the sampling intervals in both directions to generate higher frequency noise along the same direction as the large cracks. Additionally, a non-binary cutoff threshold was applied to create more negative space while still maintaining variation in intensity across the small scratches.



Finally a final set of medium-scale cracks were generated with the opposite coordinate sampling biases, creating a similar scratch-like pattern but traveling perpendicular to the main features. To provide more variation, the pattern was rotated by a random angle.

Using the initial thresholded shard silhouettes as a mask, the textures were blended overtop the current shard layer. Adding a base color and blending the surface cracks with various alpha levels creates the following textured shards.



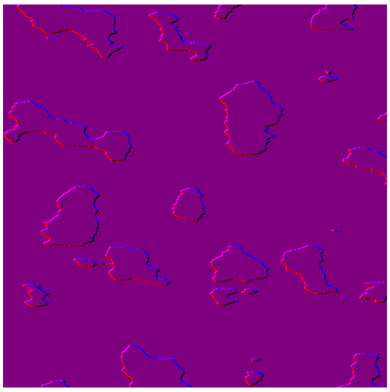
2.3 Edge Jittering

On the original image, the edges of the shards seem to have some light-colored borders in some areas, likely caused by chips from their formation. To locate the edges of the shards, a Sobel gradient convolution was applied to the shard silhouettes and then encoded into an image where the red channel stored the gradient in the x direction and the blue component stored the y gradient. The Sobel kernels

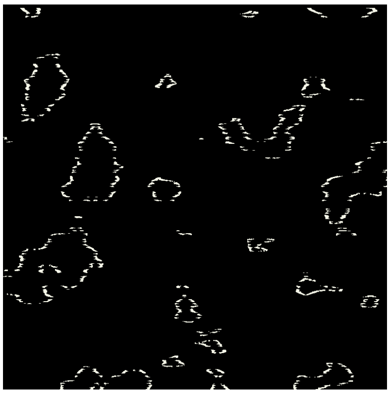
$$sobel_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

$$sobel_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

compute the gradient in the x and y directions respectively for a given center pixel once convolved with an image. The resulting gradient texture shows the output of the convolution



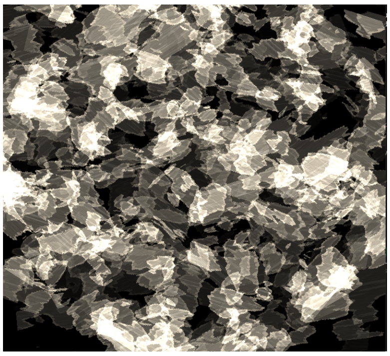
To add texture to the edges of the shards, 1 dimensional simplex noise was added in the direction of dark to light indicated by the gradient mask. This was done to ensure that the silhouettes of the shards were not effected and instead, the inner border was textured. Similarly to the cracks, the inverse absolute value of the noise was used to create ridges. This resulted in the following mask texture



Once blended with the previously textured shards, a single final shard layer was generated.

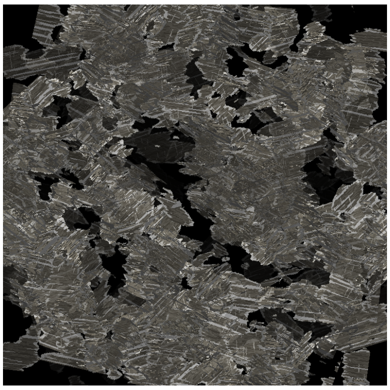
2.4 Layering

To obtain the depth of the original image, several of these shard layers were combined and blended with increasing alpha. A relatively high number of layers is ideal for creating the illusion of depth and many variations in intensity between sharps of different layers. Although the local structures examined so far have focused on the anisotropic lateral features of the shards, in the original image the shards were placed in various orientations. To achieve this, each layer is rotated by some random angle in the range $[-\pi/4, \pi/4]$. Naive layering results in a texture similar to an early prototype image shown below.



Although on the right track, the blending often results in patches of extremely high intensity brightness due to the excessive overdraw. Instead, we want to layer the only a few shards overtop each other in most areas, avoiding overblowing the regions towards white. To achieve this, at each layer we invert the image and use the currently existing empty space as a mask for blending the new layer onto. Instead of masking only areas that are pure white, we use a mask intensity that allows us to draw overtop of regions of low to medium intensity while not pushing the colors to white.

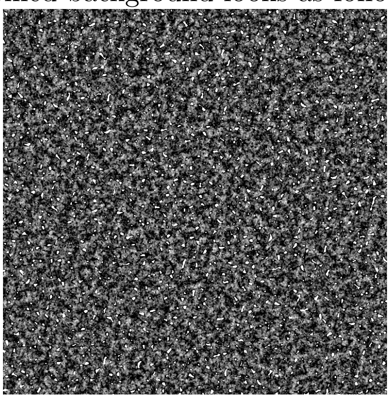
After applying this progressive layer mask technique, we are left with the following final shard hierarchy after 20 layers.



Although this masking technique creates some artifacts in the middle of shards as the mask threshold is in contention with previous layers, these fortunately create some interesting texture and actually mimic the surface of the shards on the original image quite well.

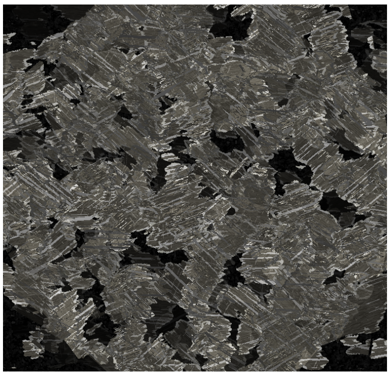
2.5 Background

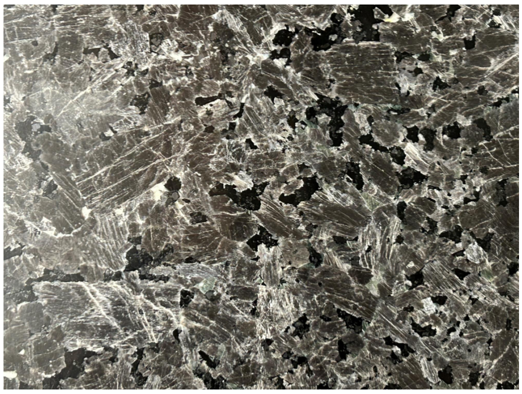
To create the cloudy background with small specular pieces, more octave simplex noise was used. Each octave was given even weighting in the summation, creating higher frequency noise and variance among regions. A cutoff was placed to create areas of pure black where the noise value is low. Higher frequency simplex noise was then used, quantizing the values at two thresholds. One for very bright specular spots and a second for medium intensity spots. The combined background looks as follows



3 Results

Combining all stages, here is a sample of a final generated texture along with the original image





For a first attempt, the final result in my eyes is good enough at approximating the general shapes of the granite shards as well as the overall surface texture when seen at a distance. The shape of the negative space regions between the shards seems to mirror the sample image extremely closely so I believe the shard generation strategy is quite sound. However, the generated image lacks the stark contrast between the shards base color and the cracks that the original has. Some part of this is likely due to the lack of lighting material properties that would allow the cracks to reflect light when under similar conditions as the photo (assuming a high intensity flash). The image rotation also introduces some discontinuities at the corners which could be ameliorated by more careful texture sizing and cropping during the generation procedure. In general, my texture lacks a photo-realistic quality and looks cartoon-like, again likely due to the simplistic crack textures. Future work should start with improving contrast along the surface imperfections, doing a more elaborate mask shard layering, and generating PBR material property textures rather than solely albedo.