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CREATING PROCEDURAL TEXTURES FOR GAMES

– with Substance Designer

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BACHELOR’S THESIS | ABSTRACT

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CREATING PROCEDURAL TEXTURES FOR GAMES

- with Substance Designer

The purpose of the thesis was to study the process of creating procedural textures, to develop a generalized roadmap that facilitates the process, and to start creating new procedural textures. The research part of this Bachelor's thesis focuses on the prospects of various tools that can be used to create modern textures for game and visualization purposes. The practical part of this thesis focuses on the manufacturing process of the procedural textures and defining the process by using one procedural texture breakdown as an example.

During the process analysis, different texture-creating software, their basic features, and the advantages and disadvantages of the process were compared.

Procedural textures developed during the work were developed using the Substance Designer authoring software. The manufacturing process consisted of 6 generalizable phases. In the design phase, target texture was analyzed and categorized into components of which the texture was composed. The practical part began with creating the foundation which serves as the base for the rest. After the foundation was completed, the details of the texture were created and then merged into the foundation. The next step focused on the imperfections of the patterns, making the texture feel more natural. In the coloring phase, the color scheme of the texture was created by imitating the reference pictures to ensure realism of the texture. In the final phase, the focus delved into creating parameters that can alter the texture. When the value of variables is changed the texture is procedurally modified resulting in numerous variations of the original texture.

For the development of the manufacturing process, Interviews produced by 80 lv site with game development professionals about the process were reviewed. In addition to this, during the thesis, 10 procedural textures were created for Morrow Games Oy, the commissioner of this thesis to assist in the more detailed research of the process, and to grow the texture library used by the company. The roadmap was created with practicality in mind and can be used to create textures that are ready for use.

The completed products were created successfully using the manufacturing process and immediately were utilized in the company's existing projects and will be possibly used for future projects.

KEYWORDS:

Game development, Substance Designer, Alleghorithmic, Substance Painter, Procedural texturing, texturing, Unreal Engine 4

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Jussi Jantunen

PROSEDUURILLISIEN TEKSTUURIEN LUOMINEN

- Substance Designerilla

Opinnäytetyön tarkoituksena oli tutkia proseduurillisien tekstuurien valmistustapaa ja kehittää yleistetty valmistusprosessi, jonka avulla prosessiin on helppo tutustua ja aloittaa omien proseduurillisien tekstuurien tekeminen. Opinnäytetyön tutkielmaosuus keskittyi pelialan yleisimpien teksturointityökalujen perehtymiseen, joilla on mahdollista toteuttaa nykyaikaisia tekstuureja peli- ja visualisointitarkoituksiin. Työn käytännönosuuden aikana paneuduttiin luotujen tuotteiden valmistusprosessin kehittämiseen sekä yhden valmistuneen tuotteen osittamiseen suunnitelman mukaisesti tarkentamaan prosessia.

Prosessia tutkittaessa vertailtiin eri ohjelmistoja tekstuurien luomiseen, niiden perusominaisuuksia, sekä hyviä ja huonoja puolia prosessissa.

Työn aikana valmistuneet proseduurilliset tekstuurit kehitettiin käyttämällä Substance Designer authoring -ohjelmistoa. Valmistusprosessi koostui 6:sta yleistettävissä olevasta vaiheesta. Suunnitteluvaiheessa kohdetekstuuria tutkittiin ja jaettiin yksityiskohtiin, joista tekstuuri koostui. Käytännönosuus aloitettiin luomalla perustus, jonka päälle kokonaisuus rakennettiin. Perustuksen jälkeen kehitettiin yksityiskohtia, jotka yhdistettiin perustukseen. Seuraavassa vaiheessa keskityttiin epätasaisiin, jotka tekevät tekstuurista luonnonmukaisen. Värittämisvaiheessa tekstuurin värimaailma luotiin ottamalla mallia vertauskuvista luonnollisuuden takaamiseksi. Viimeisessä vaiheessa paneuduttiin säätöarvojen kehittämiseen, joita muuttamalla tekstuurin arvot vaihtuvat ja luovat useita erinäköisiä lopputuloksia proseduurillisesti.

Valmistusprosessin kehittämistä varten tutkittiin 80 LEVEL sivuston tuottamia pelialan ammattilaisten haastatteluja prosessista. Lisäksi yritykselle tuotettiin 10 proseduurillista tekstuuria auttamaan prosessin tarkempaa tutkimusta, sekä kasvattamaan yrityksen käytössä olevaa tekstuurikirjastoa. Suunnitelma rakennettiin käytännönläheiseksi, ja sen pohjalta voi luoda käyttövalmiita tekstuureja.

Valmistuneet tuotteet luotiin suunnitelmaa noudattaen onnistuneesti ja päätyivät välittömästi yrityksen käyttöön nykyisiin projekteihin sekä mahdollisesti tuleviin projekteihin.

ASIASANAT:

Pelikehitys, Substance Designer, Proseduurillinen teksturointi, Unreal Engine 4, teksturointi

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LIST OF ABBREVIATIONS AND VOCABULARY

Abbreviation	Explanation
Texture	Image that is seen on the screen
PBR	Physically Based Rendering
Shader	Algorithms that handle rendering images
Object	3d model or other type of asset used
Material	Combination of textures for final rendering or combination of details which create elements
Rendering	Computer calculating final image that will be shown
Renderer	Handles how the image is calculated
Node	Function that can have different kinds of uses
Node based	Combining nodes to get the result
Pixel based	Each and every pixel is colored 1-by-1
Vector based	Computer generated that isn’t bound by pixel’s resolution
UV-map	Map that hold 3d models surface data
Map	Used to express texture sort
Detail	Information that defines shapes or colors
Output	Information that is coming out of software or node
Mask	Specific texture that is used to hide something
Alpha	Controls transparency of texture
Procedural	Generated procedure
Noise	Generated grainy texture
Grunge	Dirty texture used for its dirt properties
Handpaint	painted manually and meant to look that way
Rgb	Red/Green/Blue

1 INTRODUCTION

Commissioner for this research is Morrow Games Ltd. a Finnish game company based in Turku. Company has previously released one Escape the room styled Virtual Reality game on steam and now wants to expand its range of expertise but the problem is that many fields of 3-dimensional development need an easily scalable texturing workflow to cut down the development expenses.

This brings the topic into one of the biggest challenges in modern 3d development; Creating convincing and immersive 3d worlds requires enormous resources in order to create all the little details and 3d models that the 3d world is composed. All these 3d models then need to be textured with impressive quality to meet the high expectations that users might have. (Warren 2017.)

For this purpose it is important to constantly research and test out the latest trends that the pioneers in the industry are using to improve the quality and cost-effiency of their work. One of the latest trends is to move towards to procedural generation of textures that can be easily modified with texture variables. Doing so increases the usage of completed textures and decreases the amount of time needed to create unique variations from textures. (Geek 2015.)

The focus of this thesis is in creating a roadmap for procedurally generated textures that can be used in games and architectual visualizations. This roadmap not only will help with the manufacturing process of modern game textures but will also enables to understand the essence of textures.

The research part of this thesis concentrates on the basics of texturing and common knowledge of texturing softwares. Introduced softwares are chosen from the softwares that have been mentioned while researching for information about procedural texturing process.

Practical part of thesis consist of designing procedural textures and building them with Substance Designer. Designing goes through the process of deciding a list of textures that a project might need and then explains the analyzis process to breakdown a single texture into smaller details that can be utilized during the construction. The building process is breakdown into six separate modules to ensure that the process is kept vivid and simple. Additionally, the process is explained by using one procedural texture breakdown as an example.

The conclusion goes through the objectives, what was learned, what would be done differently, achieved results, what was innovative compared to what others did, what was to be further elaborated, the prospects of the future, and how the thesis could still be expanded for its topic.

2 COMMON TOOLS FOR TEXTURING

2.1 Brief info about texturing

A texture also known as bitmap or texture map is a 2-dimensional image file that can be applied onto the surface of any 3d model to add color, texture, or other surface detail like glossiness, reflectivity, transparency, normal, height, roughness and so forth. Texture maps are developed directly to UV maps that are unwrapped from 3d models. These texture maps can be made by separate software meant for that work or generated automatically with algorithms. Uv map is the surface of 3d model projected as x -& y -coordinate positional information into 2d plane like an unwrapped origami. Texture maps are usually painted directly on top of the model's UV map, which can be exported as bitmaps from any 3d software. (Justin a 2017.)

As the name suggests, the most obvious use of the texture map is to add a color or texture to the 3d model's surface, with texture maps you can add both simple and complex details that have huge impact in texturing besides the base color and the shape of a 3d model. In the texturing process, the color map of the 3d model is usually only one part of the texture map, of which almost every 3d model is made up. (Justin b 2017.)

Another of the most indispensable map types is normal maps. This texture map is a little more complicated and more versatile than a color map. Normal maps are a type of texture map that helps to create more realistic results and add detail on the surface of the 3d model. This map, however, does not really change the surface of the 3d model, but creates the illusion of depth. (Justin b 2017.)

A more realistic texture map from a normal map is an height map that can modify the surface of 3d model. The height map moves the surface of the model to fit the map correctly. This map is on the in popularity as the power of modern computers has started to increase considerably in recent years, raising the computing power can be used to render more complex 3d worlds and more complex textures.

Texturing can also be done with only a color map, but in this way the textured 3d model would not generally be very impressive in final rendering. This is because the light responds differently on different textures depending on the shape of the surface.

For this, there are several texture maps that creates additional details on surface or affects how the light behaves on the surface of the texture. Of the additional maps of modern texturing most common textures rough maps, transparency maps and metallic maps. (Justin b 2017.)

Roughness map determines how the light is reflected from the texture or other surface details. Every texture's surface has its own natural way to reflect light. Additionally, the texture may have some dirt or wear on the surface that could possibly modify the way the light reacts on the surface.

Transparency map literally modifies which parts of the texture are transparent. They can effectively create gaps in the 3d model without the need to modify the model physically. For example, a transparency map can be used to create hole holes in a paper basket or to create a space between fence boards. (Justin b 2017.)

The metallic map determines how closely the texture resembles naturally occurring metals. Before making metallic maps was very difficult because the natural surface of the metals was very difficult to reproduce. Fortunately, the metallic maps these days use the correct values of the metal surface to facilitate the process considerably

Alternatively, it would be possible to model all 3D model shapes and details by hand in a 3d modeling program, but this is not usually the most effective way for the intended use and it would take considerably time to create them. It is therefore important to create as much as possible using the textures. Modern games use a lot of extra texture maps to create realistic and efficient 3d worlds. With additional texture maps it is possible to create nearly as good quality results as with high-resolution 3d models. (Justin b 2017.)

2.2 Texturing tools

Before going into process of creating textures it's important to know little bit of texturing softwares and their features. These softwares were chosen from a list that both commissioner have used and writer has background in using them. Common texturing softwares in the list were Adobe Photoshop, Quixel Suite, Substance Painter and Substance Designer. There is a lot more available texturing softwares in the market listing and comparing all of them would be steering the focus from the main part of the commission which is to grow commissioner's available texture pool that can be modified and used in their project as cost-efficiently as possible. This way the experience from both parties can be used and the scope stays relevant in thesis.

Photoshop

Photoshop originated as a photo manipulation software in late 1980's and later found its way into game industry where it became commonly used tool for texturing in the industry (Craig 2016). While Photoshop was created for photo manipulation it offers wide variety of tools for digital painting. These features allow users to freely handpaint different kind of textures or manipulate pictures into either uv maps or 2d assets to fit for their artistic styles.

Lately Adobe Photoshop has been in decline in popularity due to new contenders emerging which are outclassing Photoshop with new features and workflows that make creating textures a lot faster and easier. Other reasons for decline is that this generation of textures need more and more complex texture maps with multitude of different outputs which would be later combined into final texture. This process of creating separate outputs needed for final texture can be tedious and hard work in Photoshop that require long time to master.

These days Adobe Photoshop can be mostly found within the heart of creating 2d games and as a supportive tool for other newer texturing tools that are focused in 3d art. There are still some fields of specialized tasks that are easier to do with photo manipulation software than in softwares that are fully focusing in texturing 3d assets. Most notably tasks are creating mask textures which are used to determine working spaces for textures to use in other softwares, 2d games, color correction maps and creating handpaint stylized textures. (Adobe 2017.)

Quixel Suite

Quixel Suite is Scan based Physically Based Rendering texturing plugin for Adobe Photoshop which allows user to import 3d models into photoshop and texture them without the need to constantly export them just for quick preview of the progress. Physically Based Rendering more commonly known as PBR is a technique that accurately represents the way light behaves when it hits an object in the 3d world.

Quixel Suite is designed so that the artists can rapidly create very high quality and realistic materials in Photoshop, with 3d viewport and PBR shading that determines how the image is shown on the screen. It has options to use scanned textures to create photorealistic textures from scanned pictures using generators to combine scans into usable used which can be used in the software. Quixel also offers their own scanned texture library with thousands of ready to use materials to help create the texturing process. (Quixel 2017.)

To create realistic objects, it’s crucial to be sure that the materials have some signs of wear. Object needs to feel like it has been used. This can be achieved with masks or controlling the textures by hand painting. Let the software do the labor work and you can focus on the fine details and modifying the materials. (Quixel 2017.)

The editor also allows user to use familiar tools from Adobe Photoshop and enhance them with new features and tools. It offers different kind of mask textures, enables to modify texture size, contrast and various other parameters. Another big thing that it also offers is, that everything that can be used in Photoshop can also be used in Quixel Suite’s 3d viewport for example like custom brushes.

Quixel Suite plugin available for Photoshop which offers features that will enhance Photoshop into full-fledged 3d texturing software. Including previews and renderers that are essential in reducing the iterations and time needed to achieve the wanted results.

Substance Painter

Substance painter is relatively new texturing software that offers new workflow for 3d digital art; It was quickly adopted by large digital art companies and lately found its way to essential software's collection of many amateur and indie artists.

Substance painter allows to paint simultaneously with all the possible texture channels in real time including diffuse, roughness, metallic, height, ambient occlusion and normal maps straight onto 3d model or 2d texture map within the program. Inside the software's viewport it is possible to easily switch between 3d and 2d space or have them both side-by-side. (Alleghorithmic 2017.)

Viewport uses PBR shaders which can customized or used in target platform's shaders allowing to preview the progress of textures in real-time the way it would look exactly like in the preferred engine.

Workflow consist of importing model into the program, baking multitude of maps from imported high poly 3d model into low poly 3d model or importing them from separate source if these are made in different software then these can be painted on with textures from collection or creating them with generators, masks and material variables included in the software alternatively if the needed method isn't included in default collection it can also be script or downloaded from external source. All the materials and functions are layer based so it's possible and encouraged to mix them together. (Alleghorithmic 2017.)

When the final render is finished the target platform is simply selected and it will generate needed texture maps in resolution of choice that are ready to be imported and used for 3d models.

Substance Designer

Substance Designer is unique in comparison to other listed texturing tools while other softwares are focusing on painting and applying textures over the mesh whereas Substance Designer is node based material authoring tool to procedurally generate the definite textures that are combination of the material you're creating. Doing so the software achieves non-linear and non-destructive way of creating accurate materials for 3d models. (Kirill a 2016.)

Substance Designer like Substance Painter offers all the tools needed for 3d model texturing so that you don't need any separate software between modeling software and engine. This reduces the time taken from actual creation process which used to take a lot of time to get right with all the switching and testing between different softwares.

While it is possible to do completely procedurally generated materials vector images or other pictures can also be used and then further enhanced with procedural generators and calculations achieving almost infinite amount of variations from same material.

Substance Designer can be a great texturing tool that offers a high-class, unique combination of process-based surfaces and image-based materials. Substance Designer offers a fully procedural fast and reliable PBR workflow, enabling to easily figure out what the surfaces look like when they are ready. Substance Designer offers constantly new interesting features that are easy to match with certain workflows or scenarios. (Anthony 2017.)

2.3 Tool comparison

There was a very limited available information about comparing these texturing tools so the biggest differences could be come from the features. Quixel Suite, Substance Painter, Substance Designer all three of them had very similar features while Photoshop clearly stood out of the rest due to it not being specialized in texturing. (Table 1.)

Since there weren't any real differences between the 3 specialized programs not even in the workflow except for Quixel Suite being a plugin, they are all valid options for creating textures for games. Photoshop could be recommended only if there was a large amount of skill acquired beforehand which would speed-up the creation process. Still it would be easy transfer to Quixel Suite or Substance since they have very similar layering and painting system. This would open all the extra features that Photoshop is missing for efficient texture creation.

Additionally, there is a lot of different viable texturing softwares that can be used in the todays marketplace. These four softwars were selected into comparasion because their working methods are very similar to each other and transition between these programs is almost flawless.

Table 1. Comparison of features

Feature	Photoshop	Quixel Suite	Substance Painter	Substance Designer
PBR	No	Yes	Yes	yes
Method	Paint	Paint	Paint	Generated
Renderer	No	Yes	Yes	Yes
Library	Yes	Yes	Yes	Yes
Resolution	Unlimited	Up to 8k	Up to 8k	Up to 8k
Multichannel	No	Yes	Yes	Yes
Baking	No	Yes	Yes	Yes
Converters	No	Yes	Yes	Yes
Multioutput	No	Yes	Yes	Yes
Texture type	Fixed	Fixed	Fixed	Procedural

Texture scan	No	Yes	No	Yes
Tiling	Manual	Manual	Manual	Automatic
Smart	No	Yes	Yes	Yes
Scaling	No	Yes	Yes	Yes
Workspace	2d&limited 3d	2d & 3d	2d & 3d	2d & 3d
Masks	Yes	Yes	Yes	yes
ID map	No	Yes	Yes	Yes

3 DESIGN

3.1 Designing textures for Substance Designer

Designing begins with analyzing what kind of assets a project would need and listing them. When every asset is listed then assets are inspected one by one to see what kind of textures they are composed of. Next the texture information is processed to make a list of unique textures needed. Everything texture that is made of same material can be combined into more generalized texture for example there is no need to have 3 different color painted walls because their base material is same a painted wall.

Once the list of textures is completed it’s time to search reference pictures which will serve as a base for analyzing the material itself behind a texture. The material is breakdown into 5 separate categories because it’s much easier to notice what the material is made of and it will help to reproduce the shapes and the details while recreating them into texture inside Substance Designer.

First category is base shape of the material, does it need a shape or is it flat? If it isn’t flat material then the shape is broken into smaller pieces which creates the more complex shape. Only the base shapes should be thought of here without all the imperfections that there could be.

Second category consist of rough details of the material. How it is damaged, how old it is, weather damages? Everything from big cracks to natural patterns of a wood is considered to determine how it became like it is today from its perfect state. Basically, everything that is an effect of outer source. This category is helpful when there aren’t exact reference pictures which could be copied straight away. By analyzing what could cause for certain details to appear on the material, can be used as an information for recreating them in practical phase of the work.

Thirst category is fine details which can also be called materials micro surface which is really fine detail can be barely seen. What is natural surface for the material? How does it feel when touched? Is there small imperfections or cracks forming naturally? How light is reflected on the surface? While these can be minuscule, hard to notice and may sound as nitpicking on the small details, it’s still truly important part of the material which takes it into next level of details. Every material has them even glass! So, it isn’t something to ignore since it can be a major part in the feel of the material. This also allows genuinely close inspection of the texture without it losing details. Additionally, even if the details can’t be seen with naked eye, light will still be adjusting to it and modify how the texture feels.

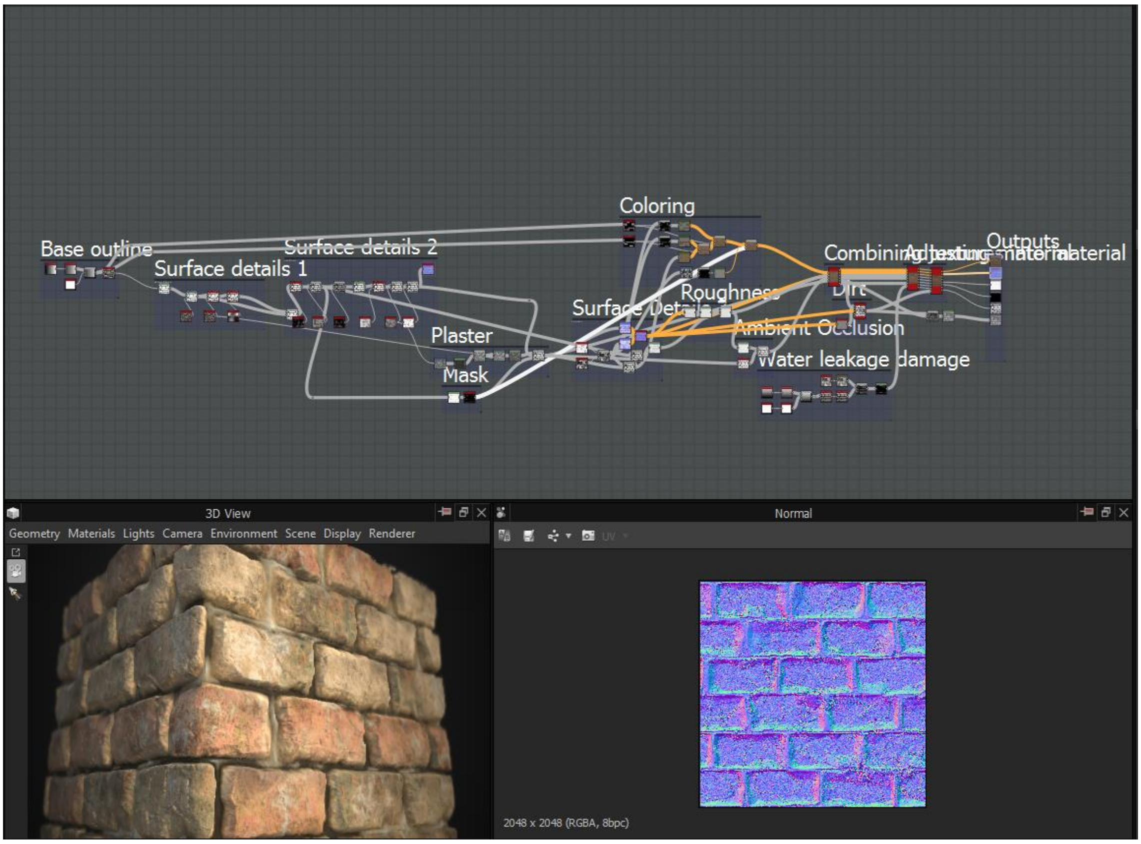
Fourth category focuses on the colors of the material. How they are composed? which detail the color belong to? Dirt? Natural color varieties? Weathering? These are some of the details that need to be considered when designing color palette for the texture. Colors have great impact in the overall feel of the texture and they are very prompt with flaws. Even the slightest difference from the natural color can become very disturbing when human eye spots it even if the person itself doesn’t be aware of the flaw. This is only true to more natural looking textures since humans associate everyday objects and colors subconsciously to things they think they know. This feature should be used as an advantage rather than disadvantage while designing color palettes; natural color palettes are great references for realistic textures and very exaggerated color palettes doesn’t have any associations in real life so there is nothing to compare to.

Fifth category the material customizability. Now that the texture is pretty much analyzed, how it behaves and what defines the texture. Question becomes: How and what can be changed within the texture that it will keep its characteristics but would still look different? This will serve as a base for creating texture variables to customize textures. These variables can affect almost any part of the texture but not the texture’s material itself without making it into completely different material. It sounds complex but when the definitions are clear there shouldn’t be any problems designing customization variables. Usually they are shapes, patterns, texture color palettes, and so forth.

4 PRACTICAL IMPLEMENTATION

4.1 Creating textures with Substance Designer

Since giving universal guideline for creating materials simply cannot exist. This section will be using one material breakdown which was created during the practical part of this thesis as an example. In this case a tile able old brick wall will be great example since it’s relatively small graph and it can be easily separated into different sections (Picture1).



Picture 1 General view of material. Jussi Jantunen 2017

After designing the textures what you’d like to do and finding good reference pictures you’re ready to begin the fun part of texturing. First time opening Substance Designer might be confusing but when you get familiar with it you will realize that it’s quite logical. When you create your first project the software will automatically generate the basic outputs that you can immediately export into textures. One might start to explore the different tools available in UI but it gets really confusing and hard to find the things you need and want to use.

Substance designer isn’t designed to be used by visible UI nor by hotkeys. Nobody really wants to learn all the complex key combinations to work with and UI based workflow just isn’t that practical in long term. The answer is indexing all the resources and just by pressing space or dragging output from a node will open an index window where you simply type what you’re looking for and it will find it for you. This allows the workflow truly to be easy to learn and efficient same time. (Alleghorithmic 2017.)

While creating procedural textures with substance designer it’s advisable to keep the workflow quite modular as well to keep it clean and logical. Keep in mind that the best way to do things for others might not be the best way for you.

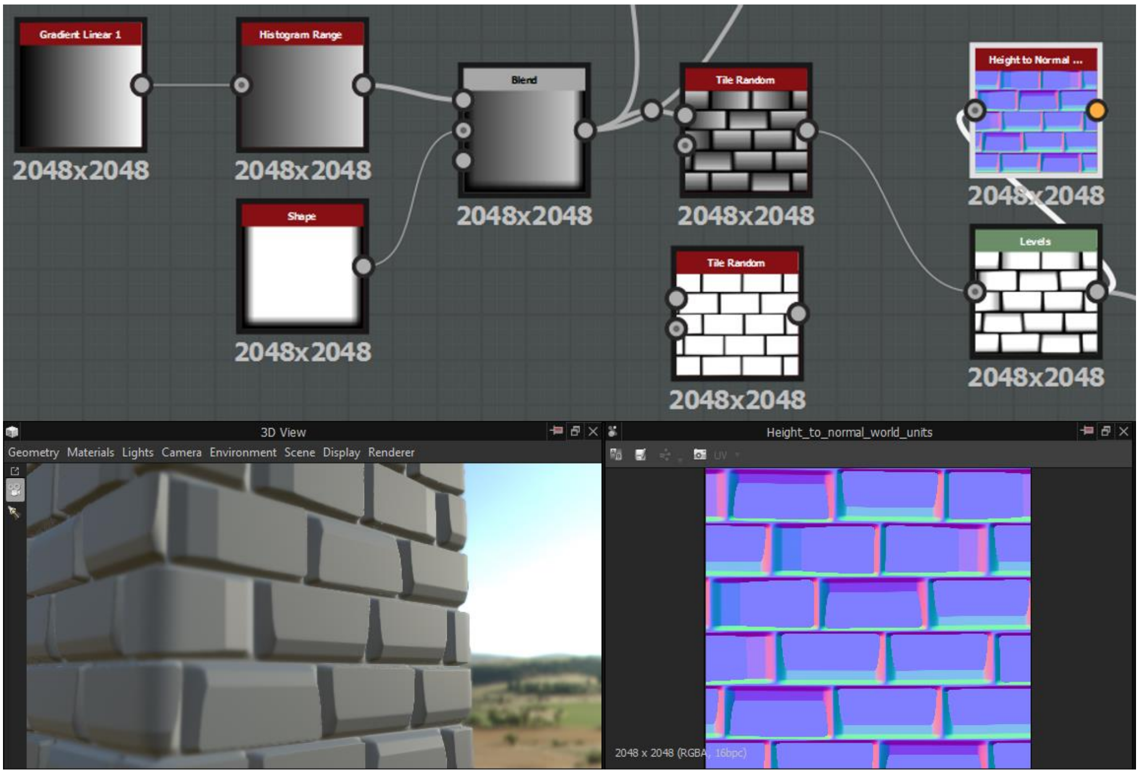
4.1.1 Creating base outline

Work begins with creating simple shape in this case a round edged square by blending wanted shape and gradient smoothed with histogram filter to give it smooth edges and room to freely modify the slopes of the shape.

After that the shape is inputted into tile random which has different properties to adjust the tiling for example the number of horizontal and vertical tiles and the space between them. Substance Designer also has its automatic tile generator but it would limit the possible variations so it is sometimes better idea to create the wanted shape yourself before inputting it into tiling node. This ensures that you can modify the tiles to fit any style that is required to give realistic feeling to the material.

The output image still has a large range of gradients and using that would give the final image huge difference in height and very sharp edges so it must be leveled into wanted range with levels node. Levels node is quite simple but powerful node that allows to modify the input image’s gradient levels. Almost everything resolves around the gradients in Substance Designer since it controls the height hierarchy, shapes and can be turned into almost every other type of map automatically with different nodes and generators thus, the levels node is one of the most crucial and used node.

Now the material’s base outline is completed. It should be kept simple and clear so it can be modified later. Every node inherits all information from its parent node and will be using this information as a base for the defined functions within the selected nodes. This is one of the key elements in this kind of procedural work flow. (Picture 2.)



Picture 2 Creating base shape. Jussi Jantunen 2017

4.1.2 Adding rough details

Now that the basic shape is defined the material needs to have its own personality or it would feel unnatural and boring. This phase could be thought as extension to basic shape although it is a bit more complex there shouldn't be too many cornerstones once the principles are clear.

The basic principle is pretty much that the work begins with blending big shapes into base outline by blend node and multiple noise nodes and gradually moving to smaller details. Mostly used nodes for this stage are warp, Perlin noise zoom, blend and different kind of blur nodes. Different noises are generated with algorithms and they modify the pixels of image in fixed order to distort the images in predetermined way (Ken 1985).

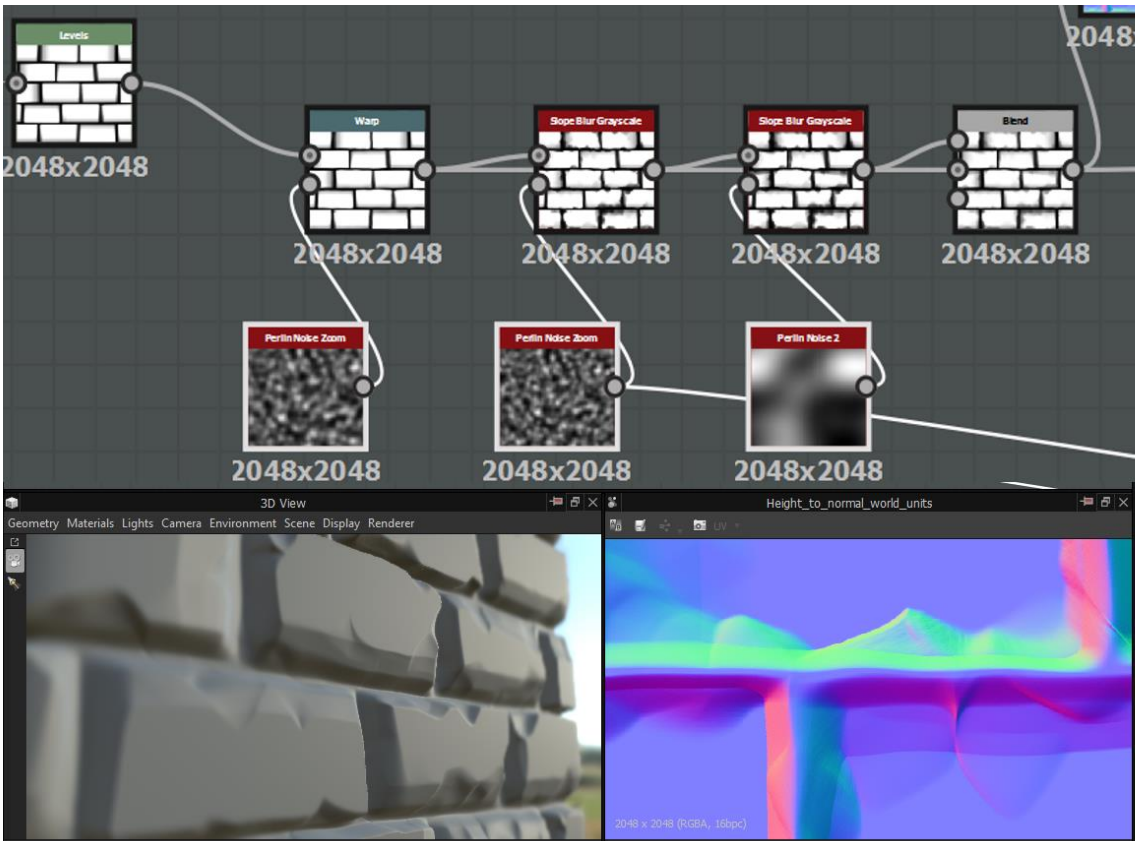
Warp node simply warps the input shaped with the selected shapes and then combines them into 1 output. As for Perlin noise zoom it is an algorithm which is mostly used to create computer generated motion surfaces; because it's fully computer generated it can be zoomed to generate different shapes which is ideal for procedural materials.

Blend in Substance Designer behaves like any other software that uses layering; simply comparing the two inputs and then combines them into final output. User has few options to modify the blend for example the power of secondary image's blend and different types of blends. Most commonly used type is basic multiply mode which simply starts to blend the two inputs linearly from primary input to secondary input.

There is a couple of types of blur and they all have their own uses. Simplifying the blur nodes, they all share the common functionality that they find differences between gradient levels and then blur them to round the difference thus they are used to remove of extra sharpness from edges and unwanted graininess from surface.

For this case as the material is old and worn-out brick wall; the base is inputted into warp node and then warped with Perlin noise zoom which takes away big chips from the edges. Then output is connected into Slope blur node with another Perlin noise zoom with different zoom level to add more chip damage to edges. This procedure can be applied repeatedly with multitude of noises until the wanted shape is achieved. Usually it is repeated multiple times as one big line which always adds the effect over to last output or it can be separate instances to modify different parts and then later combined into one output with blend node to give it natural feeling.

Brick wall's edge damage isn't very complex so combining two Perlin noise zoom nodes with large scaled Perlin noise 2 node is enough to achieve wanted results. Last step is to blend the output with itself to smooth everything out to remove unwanted chip damages. (Picture 3)

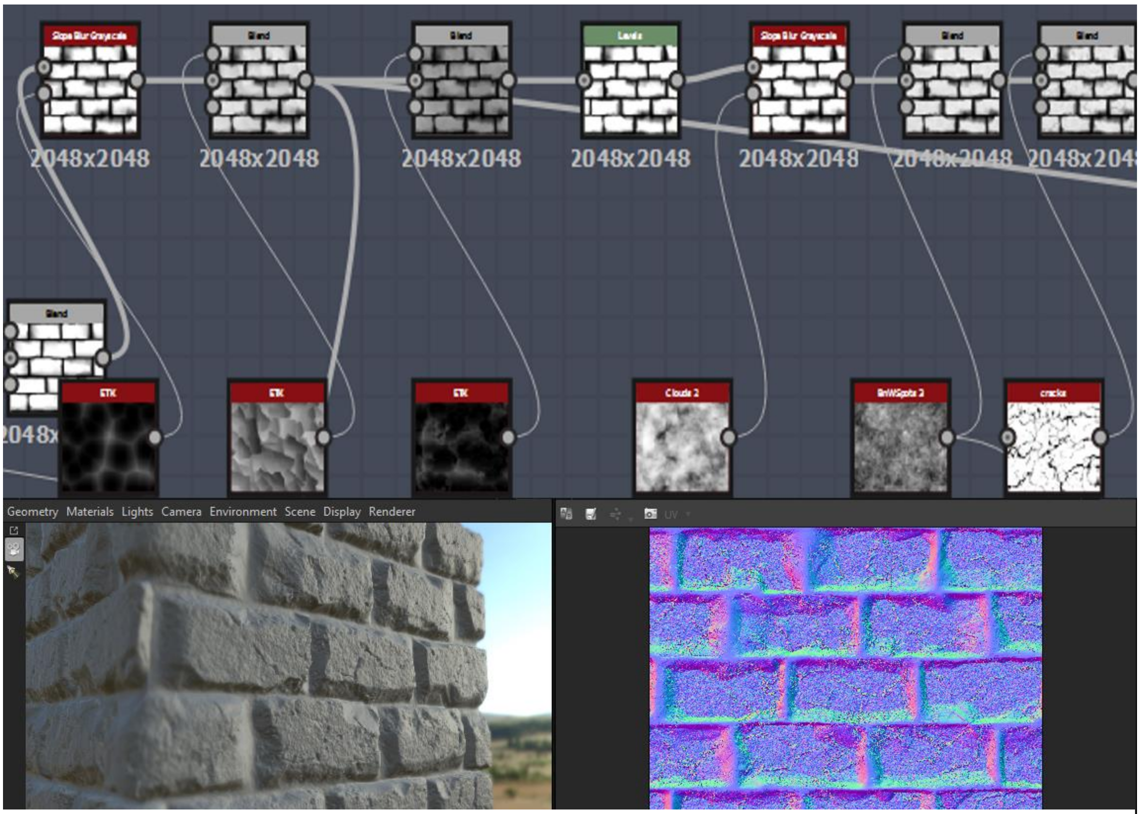


Picture 3 Adding rough details. Jussi Jantunen 2017

4.1.3 Fine details

After the large details has been added it's time to start adding finer details to surface of the material. Surface details are pretty much a like the previously created rough details. Nodes used for this are same and principle is same also but there are more blend nodes rather than blur nodes in this phase. First large shapes are added like for example dent or cavities with Slope Blur node then moving onto finer details like big cracks and erosion using blend nodes. (Picture 4)

When blending a lot of different textures together it's important to modify gradient levels because blending textures with different gradient levels starts to affect the output node little by little. When moving into next type of blending it can be useful to use levels node to adjust gradient levels for next detail. This way it's easier to add details to surfaces especially when the details are very miniscule and hard to notice.



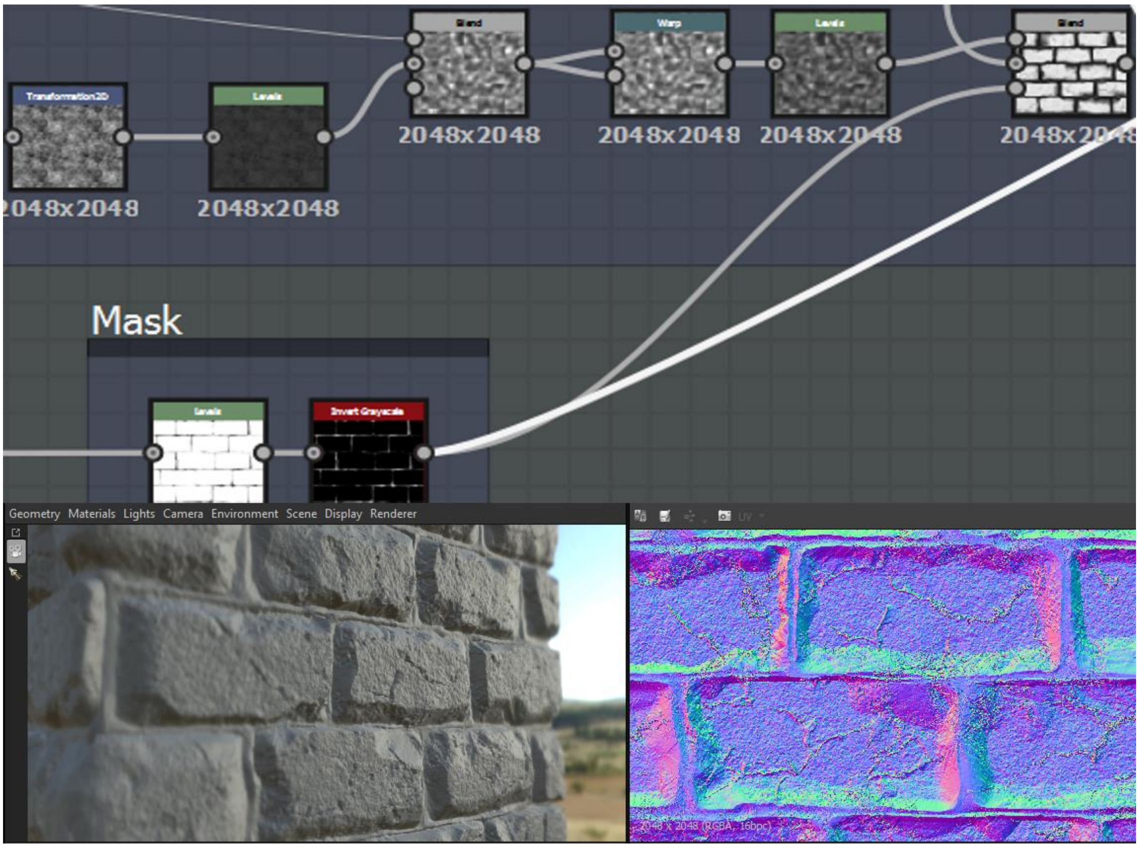
Picture 4 Adding fine details. Jussi Jantunen 2017

For this process brick wall needs some custom shapes to create randomized dents to make the bricks uneven from each other. This was merged using Slope Blur Grayscale into rough detailed shape with small adjustments. Bricks also have uneven surface even when they are new thus it needs some almost block-like shaped edges randomly rotated and tiled together on the surface. Now surface starts to shape up but since the bricks are supposed to be historic and worn they need some extra erosion to imitate weather damage. This required a little bit abstract custom shape blended into previously created output creating the extra erosion.

4.1.4 Secondary texture layers

Completed materials rarely consist of just one type of texture since it would be inefficient because creating more complex looks would require multiple separate textures to create one complete material. This also means that the single object’s textures would take a lot more memory when used and to use them one would need to do combine them in targeted platform with separate mask textures. Complete material can be combination of any number of secondary textures as the material needs to give it the wanted appearance.

There was a reason for not mentioning multi-texturing before; In Substance Designer, it's good to keep everything well organized. Constructing the material from pieces one by one in organized manner helps to keep the creation process simple and detailed. This also prevents from getting lost within the process when you're trying to finish too many things at simultaneously and it begins to feel that it doesn't amount to anything until the very last end.


Transformation2D
Levels
Blend
Warp
Levels
Blend
2048x2048
Mask
Levels
Invert Grayscale
Geometry Materials Lights Camera Environment Scene Display Renderer
2048 x 2048 (RGBA, 16bpc)

Picture 5 Creating secondary texture layer. Jussi Jantunen 2017

Creating multi-textured material in Substance Designer is straightforward and it doesn't differ much from previous steps of combining noises to combine different shapes together. Same principle is applied here once the first texture layer is created it is possible to begin creating another texture branch within the same project file or simply creating a branch from any previously used node. (Picture 5)

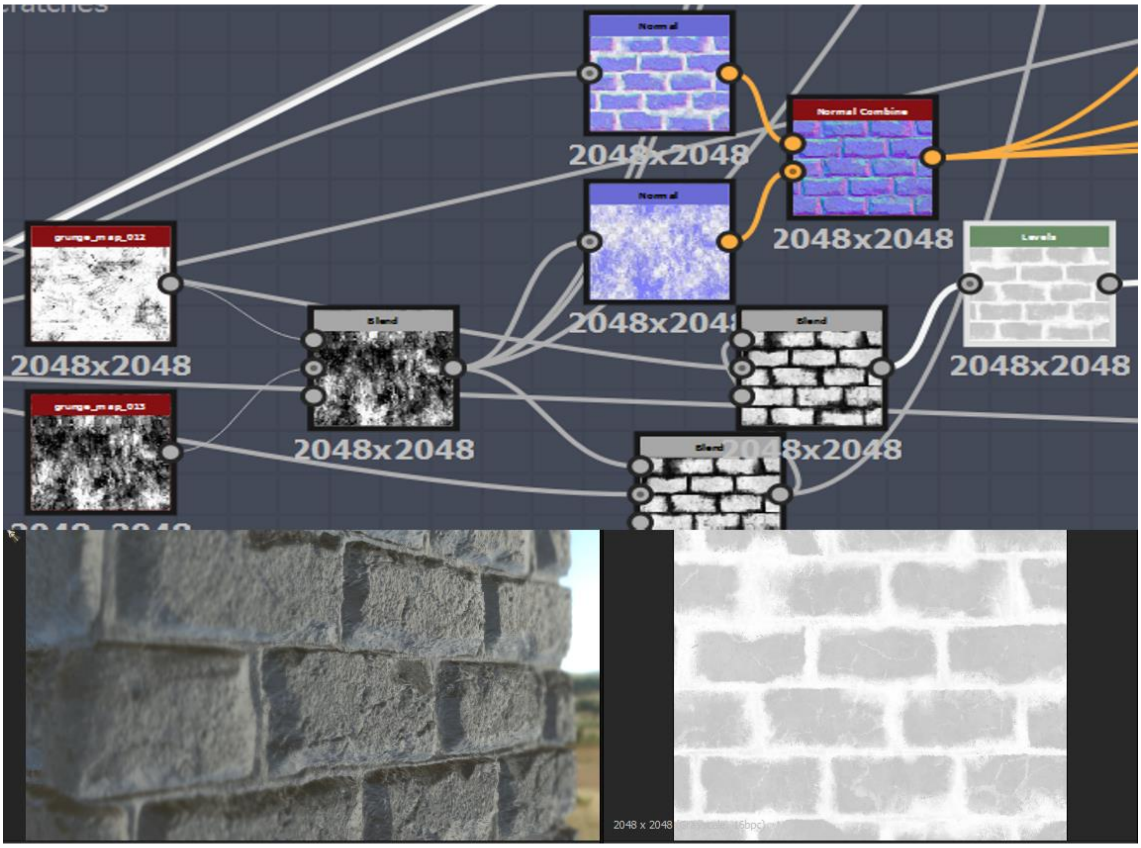
Secondary textures can be created following the same steps as the first texture to slowly construct the material piece by piece or by utilizing the nodes that were created beforehand and then reusing them. After all the pieces have been created using any technique it is then blended together by using mask texture to assign different textures to their rightful places.

Mask textures can be created within the Substance Designer itself by taking grayscale node for example from the base outline; then leveling it with levels node to reduce the number of slopes and then inverting it to get the space around the base outline. This mask is then given into blend node to instruct it to just apply the blending to the selected area and successfully combining the textures into one usable output.

4.1.5 Creating imperfections

At this point the brick's micro surface is finished but it doesn't feel natural at all because it is too perfect and equally distributed. This brings us to the last step of modifying bricks surface where the material's surface is tweaked to have randomized imperfections which can be found to occur naturally in real life. This can be achieved with different ways but one of the easiest way is to use grunge maps to add scratches and randomized shapes. Then they are combined with grayscale from the micro surface map with blend node in overlay blending mode with high opacity for secondary input. This step is repeated with various kind of grunge maps until the surface begins to feel natural and interesting to look at. When the outcome is as required it is then balanced with levels node to stabilize contrast of the details so that the surface wouldn't be too rough looking. Using this kind of technique allows very diverse final outcomes when used with different kinds of grunge maps or alternating attributes even little bit in the blend nodes.

To give nice variety to old bricks there was two grunge maps used to give it worn-out look. First was scratched metal and second was bark from old pine tree then they were combined with blend node using tree bark as background input and scratches as foreground input. This way the tree bark ended up as being the major grunge and the scratches were multiplied onto it. (Picture 6)



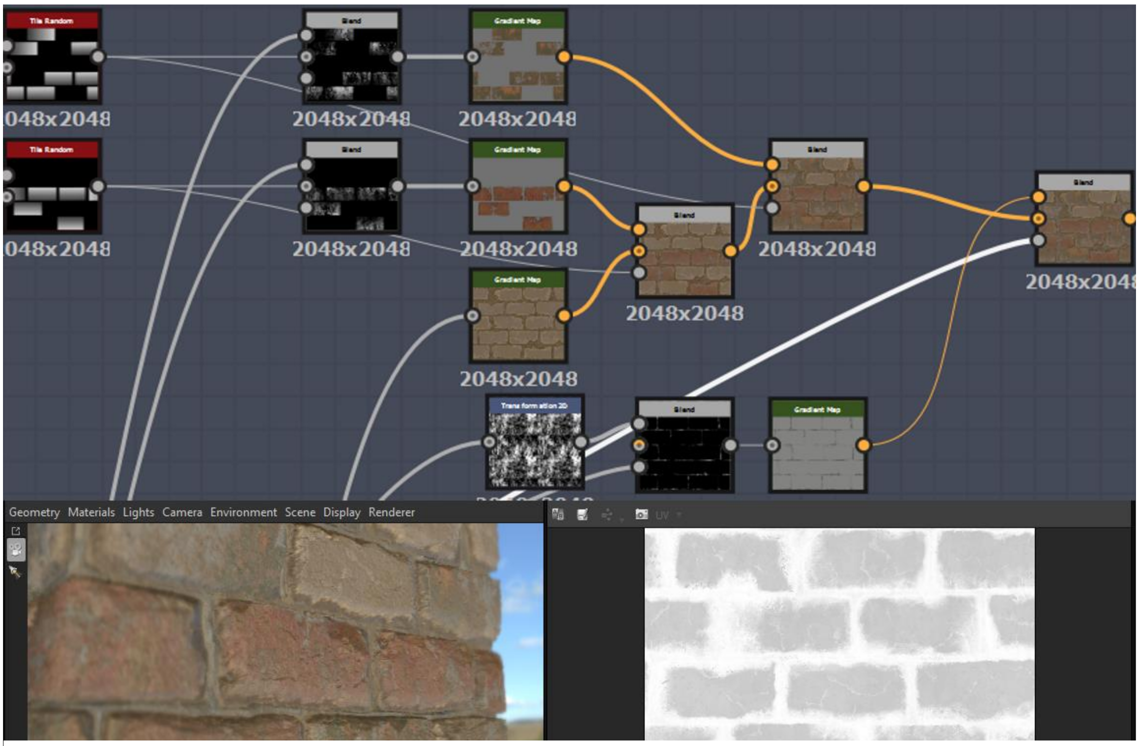
Picture 6 Creating imperfections. Jussi Jantunen 2017

Output from this node was also taken and converted into normal map that was then combined with the normal from fine details grayscale creating the final normal map. Height map was combined with fine details grayscale without any conversions with blend node but the result was unsatisfying and it had lost some of the rough details that were meant to be reserved as they were. This was fixed by blending the output with output from the fine details module and then brought into levels node to adjust the amount of differences.

4.1.6 Coloring

Colors of the texture have a big impact in creating the overall view of the final texture. It can be used to create many kinds of artistic styles from handpainted to realism and it gives the perception to the texture. There are countless ways to approach the process since there is multiple styles and the complexity varies. Although it’s a bit hard to generalize this process there is similarities in many of the approaches such as the initial input and principles.

Everything begins from the initial input which is usually a grayscale map from any given point of the texture process. The point is selected depending on how the color will be built. If the color is being built from scratch by hand, grayscale map is taken from early stages of process where only the basic shape is present. Then the grayscale map is converted into gradient map using gradient map node. Inside gradient map node color can be applied using color picker to automatically pick any color value from the computer’s screen or by inputting rgb color values manually. Additionally, the node takes



Picture 7 Adding colors. Jussi Jantunen 2017

different shades from the grayscale map this allows to apply multiple colors which are blended between the grayscale values inside a single node.

Once the base color is done the process’ principle is almost identical to creating details to the main texture. Previously created color is blended with new colors with blend nodes adding more color variety to the texture. Mask textures are used to control where the color is being added also the secondary textures can be implemented by restricting the coloring area using masks. This process is repeated for every different colored detail until the color is satisfactorily.

Brick wall’s base color was created using grayscale map from middle part of imperfection phase to give it good uneven edges and natural grunginess. Color palette was selected from reference image using automatic gradient drawing collection within the gradient node. However, the outcome was disarray of colors which had to be modified by deleting excess gradient positions and pivoting rest of the positions to fit the grayscale information.

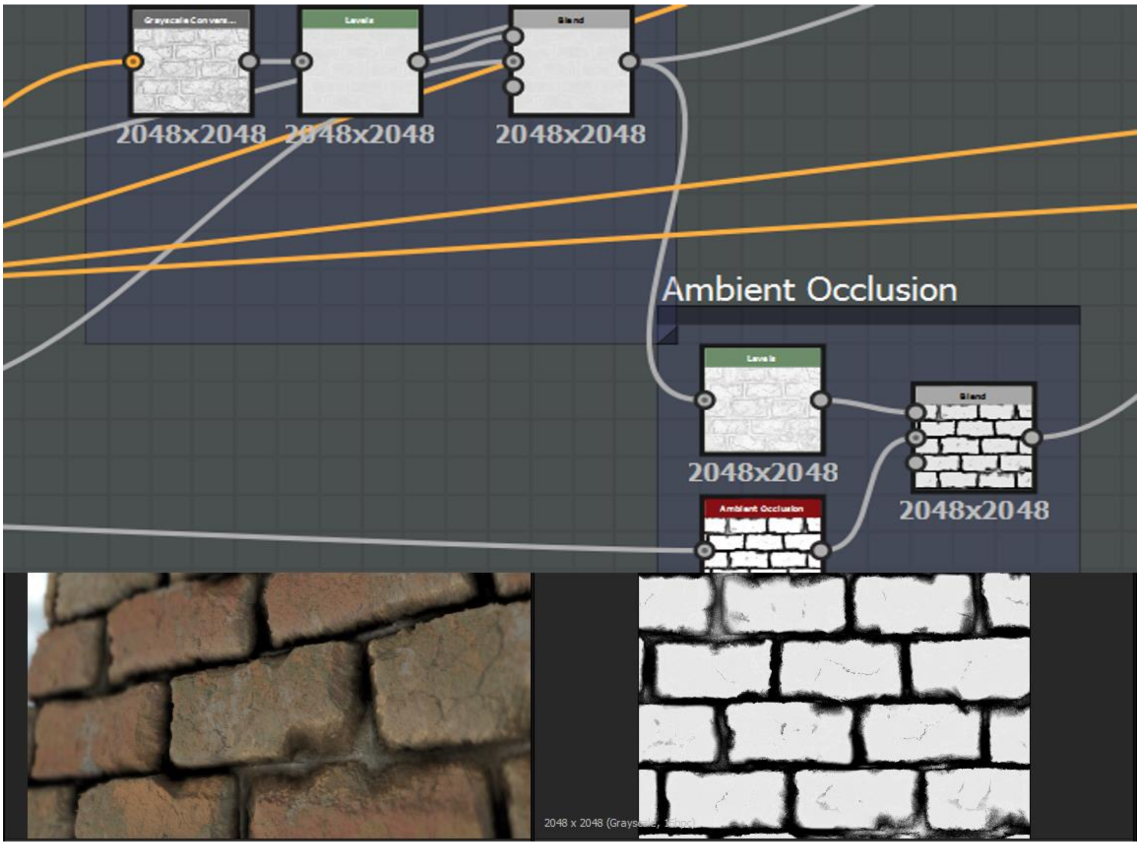
Next step was to create randomly selected different colored tiles to create variety for otherwise single colored bricks. Selection was made with copying the tile random node which was used to create the base shape for each color variety. Then inside the copied tile random node’s mask random value was changed to select random tiles from the shape. These were blended with grunge maps and converted into gradient maps. Then using the same technique as for the base color a color palette was created but this time a highlight color was mixed into 1 gradient position to give it a different shade. (Picture 7)

Lastly the brick wall needed color for the secondary texture which in this case was the plaster between the bricks. For this reason, a mask was taken from the surface details grayscale, inverted, blended with the micro surface’s grunge map and then converted into gradient map with a basic gray color. Then every gradient map was blended together using the same masks that were used to control the coloring area, creating final composition of the color texture. (Picture 7)

4.1.7 Additional maps

Modern textures wouldn’t be what they are without additional maps that can be used to enhance the basic textures into next level. Most notably are roughness, height, normal, metallic and ambient occlusion maps that were popularized when modern PBR shading became cost-effective with new technology.

Creating these maps in Substance Designer is usually done just before combining everything into Base material node which is used just before connecting everything into output nodes. This is because information to create these is taken from the grayscale map that all the previous stages have been building.



Picture 8 Creating roughness and ambient occlusion. Jussi Jantunen 2017

First normal map is created because all the other maps can be converted from it. To create normal map, the grayscale before micro surface is converted into normal map and then separate normal map from micro surface details is converted. When the intensity of these 2 normal maps is made they are combined thus becoming the final normal map.

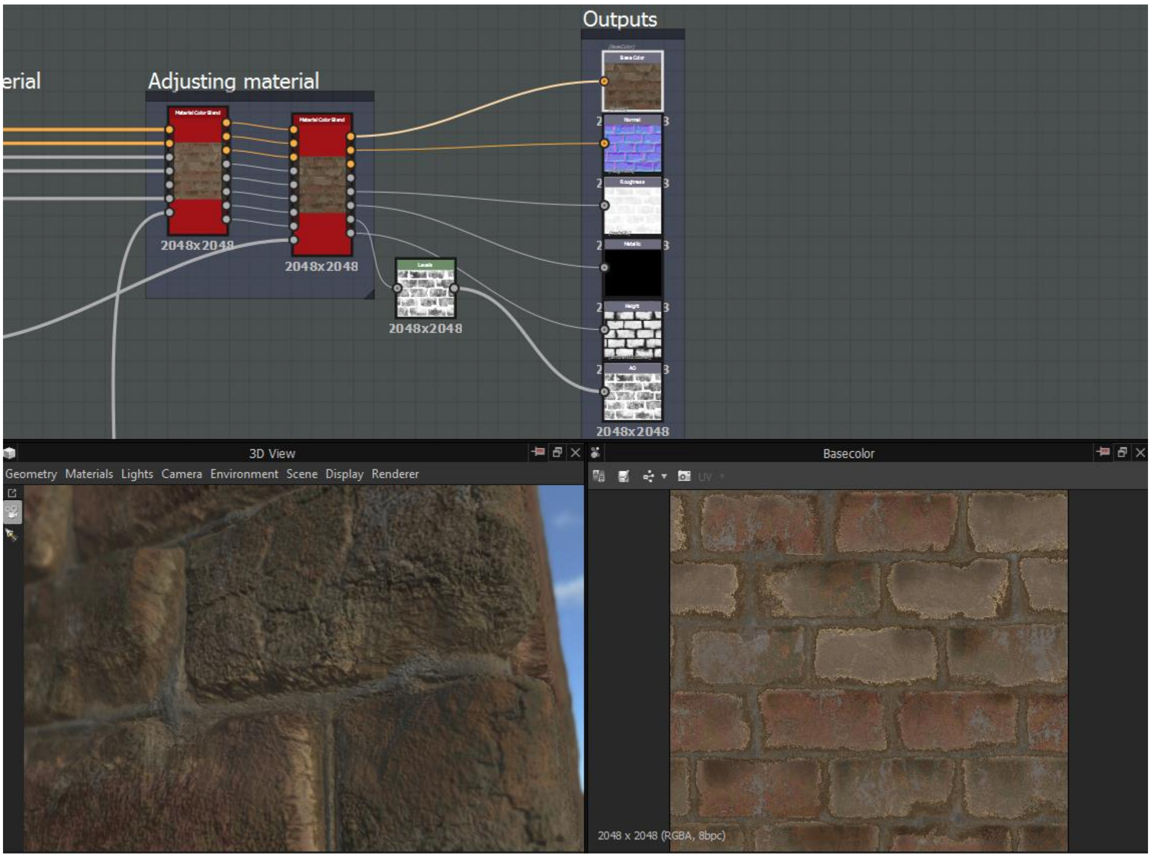
This information can then be used to create roughness map by converting the normal map again into grayscale and then blending it with secondary grayscale if there is need for additional information on how lights affect the surface of the texture. Closer the color value is to white, more roughness value is applied and vice versa the darker the color is, shinier it becomes. Metallic is pretty much the same map but it is inverted. (Picture 8)

Ambient Occlusion is used in textures for creating atmospheric shadows within the texture details. This method can be done in game engine also but it's more cost-effective to use pre-made ambient occlusion map especially if there are dynamic lights present in the game engine. (Picture 8)

In Substance Designer, there is specific node for creating ambient occlusion where you can manage ambient occlusion's spreading, levels and frequencies and then it automatically generates ambient occlusion from grayscale. This effect can be boosted with blending extra details on it or adjusting levels information.

These are just default additional maps and there is no limit on how many or how complex additional maps are created on top of the regular maps.

After every map that is needed is created, they are connected into Base Material node to combine them. Base Material is the final node where texture's modifications are fine-tuned before connecting everything to Outputs nodes. Additionally, the node takes care of making sure that every map takes information from the other maps. (Picture 9)



Picture 9 Base material node & outputs. Jussi Jantunen 2017

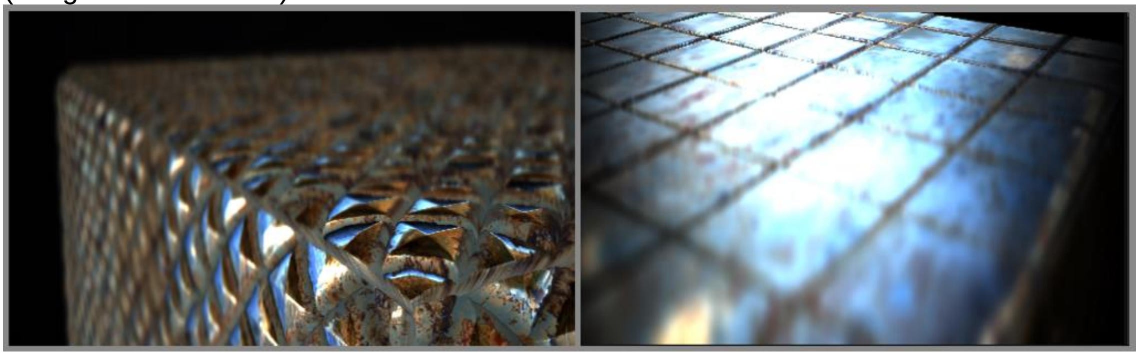
4.2 Outputs

Output nodes are just nodes that will pass information to software’s export function on what to export and how they are interpret. There are numerous options inside that will help the software to apply right texture settings for each output. These are necessary to ensure high quality and compatibility. Options include picture format, Mipmaps; and usage which has presets for different kinds of maps. For example, base color and normal maps have very different kinds of usages and need to be interpret right for them to function properly. There is no real limit on how many outputs can be exported simultaneously but in optimization point of view only the necessary outputs should be exported since everything will take up memory space regardless if they are used or not (Picture 8).

4.3 Texture variables and usage in target game engine

There is 2 ways to import Substance Designer textures into game engine. First method is to export each texture map into bitmap. Those are then imported into game engine where they need to be combined into usable material. Second method is exporting substance designer archive file and importing it to game engine. Archive file handles creating all the necessary manual work of combining textures into ready material. This method requires Substance plugin to work but it's free for everybody.

Substance designer is node based and most of the nodes have some sort of variable that can be modified. By changing the values in them even a little bit it, the information given to next node is changed which will result modifying the final texture (Picture 10). (Alleghorithmic 2017.)



Picture 10 Example of the effects of texture variables. Jussi Jantunen 2017

In Substance Designer while creating the texture it's possible to assign functions to these node variables and then expose selected variables to the substance designer archive file. This allows modifying the texture variables inside target engine within the assigned limits. (Kirill a 2016.)

These variables are not exposed by default in the substance designer archive file. There would be simply too much information and variables that could be changed that it would be hard to tell what each of them would do.

This valuable function allows fast and easy iteration process for the textures. Additionally, it also gives a possibility to reproduce textures that are made of same surface material but giving them each of their unique details. (Kirill b 2016).

5 CONCLUSION

Researching and working with the thesis subject have helped to further develop writer’s practical skills and knowledge in the path of becoming legitimate technical artist for game industry. Technology based industries are developing at shocking speed so it is crucial to stay on the crest of a technology-wave if one wants to become a professional. Game industry is not an exception and climbing the ranks can be extremely time-consuming and hard. Getting a chance to practice and master a new technology that could very well be in its way of becoming industry standard could bear a fruit in this sense as well as deepening the proficiency in adapting to vast range of tools available in the market.

The main goal of this thesis work was to upgrade the commissioners Morrow Games ltd. available texture library while looking for new alternative technologies to enhance the product pipeline, raise the cost-efficiency and the quality of products. Based on these criteria’s the goal was met. During this thesis ten procedural textures were made and added to Morrow Games ltd. texture library and they are already in use in their customer projects. Procedural textures made with Substance Designer demonstrates the possibilities of the technology with its countless features and logical workflow. Providing all the necessary tools to create stunning high-quality textures without a need of external software to support the workflow. In the future more complex textures can be made using the same principles when deeper understanding of the process and techniques are achieved.

More advanced research could have been achieved by learning more about the other softwares mentioned. For example if there would have been time to recreate similar textures using different softwares there would have been possibility compare the results, workflow and time needed to make similar texture. In future it would be best to acquire deeper understanding in every available procedural texturing software to truly know which would the best choise for creating these textures for the commission.

Be the one that defines the industry rather than the one following it!

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