AUTOMATIC NC TOOLPATH GENERATION FOR 3D SCULPTURED FEATURES EXTRACTED FROM 2D IMAGE

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CERTIFICATE

I hereby declare that the thesis entitled "**AUTOMATIC NC TOOLPATH GENERATION FOR 3D SCULPTURED FEATURES EXTRACTED FROM 2D IMAG**" is an authentic record of my study carried out as requirements for the award of the degree of **Master of Engineering** in **CAD/CAM Engineering** at **Thapar University, Patiala** under the supervision of Mr. **Ravinder Kumar Duvedi, Assistant professor,** Mechanical Engineering department at Thapar University, Patiala and **Mr. Ravinder Kumar, Assistant professor,** computer engineering Department, Patiala. During July, 2013 to July, 2014. The matter embodied in this report has not been submitted in partial or full to any other university or institute for the award of any degree.

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It is certified that the above statement made by the student is correct to the best of my/our knowledge and belief.

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(RAHUL THAKUR)

ABSTRACT

In the present work an attempt has been made for web based automation of Look Alike 3-Dimensional image design features using online application programming interface (API) environment. A web based environment has been developed for providing interactive access to automatic image toolpath generation. In the present work, the domain of 3D design features is restricted to image feature designing. The concept demonstrated in the present dissertation work can be extended for web-based automation of all types of 3D solid/surface modelling which is permitted inside any commercial CAD package supporting API based macro development. The webbased interactive API macros will help the client to choose various parameters required for look alike 3D design creation and help them incorporate their creativity to create the design they like. The design model is made available on the webpage so that the user can get a feel of what is being designed by him. When the design get finalized, the CAD model is saved in the required format at the server end. In the present work, the CAD model is saved in point cloud data format which can be further used as an input for downstream applications like rapid prototyping, NC toolpath generation or automatic assembly operations etc. The point cloud data directly is then further used for the generation of toolpath by using two methods Raster toolpath and Contour Toolpath. This toolpath file can be used with any customized machine available with customer to manufacture the feature.

The overall design strategies for creating some 3D design within some pre-defined families can be made more productive, cost effective and remotely excessive. A lot of research has been going in the field of 3D design automation and modelling which also uses Web Based application for real time data exchange and approvals. Under the present work, an initiative has been taken for development of web-enabled client based designing and toolpath generation for image sculpture on the aluminum sheet by the processed algorithms.

This is the ultimate aim of the present work is to develop an integrated design and manufacturing environment which can be used by anyone even a engineering background or a non-engineering background person or a hobbyist.

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CHAPTER-1
INTRODUCTION

At the threshold of the new century, technology can offer substantial support to all the activities of the Designers. Particularly in current years, a good deal research work has been carried out in the field of design/production and new sophisticated technology for manufacturing has been developed. 2D to 3D image processing has become a great market value in the area of image processing. The 2D to 3D image converter mainly contains the information of its depth map. The depth map contains information about its embossment up to a particular scale. It can reduce the overall cost for producing a 3D image object with the input as the 2D image data. It can express the exact feature and scenery of the 2D image data to 3D image object. In the main design process the computer aided design system, the process of generating the point cloud data information then scaling, edit/add and other model functions and aesthetically look of the finalized look alike 3D object. The present commercial CAD tools does the work with main information but not well suited for this one that comparing the 2D image to 3D object modeling. As a result, many computer based 3D model editing tool has so much costlier so that will affect the output cost for the look alike 3D object. So using without CAD tools, if a algorithm can change a 2D image to 3D become an emerging research for the recent years.

Computer Aided Designing (CAD) plays an important role to reduce the cost of the design and manufacturing. CAD system coupled with Computer Numeric Controlled (CNC) system or computer aided manufacturing (CAM) systems enhance the potential of profitability for customized products. The integrated or combined CAD and CAM systems also serves as a great tool for the artisans and craftsman to produce identical designer product with more accuracy, quality and repeatability at shorter times.

The product life cycle starts with the need of the customer followed by concept of the product till the manufacturing and production of the product. Similarly, for a product in a manufacturing company, the cost of the CAD/CAM system (fixed cost) gets distributed over a large number of products. However, for a small scale production or for customized production system, the cost is too high for designing and manufacturing owing to high fixed and running cost of automation system like CAD and CAM systems. Thus, it is not economical to buy a CAD/CAM system package for small scale production of customized product and this is also less popular in

industries or else the customer should be ready to pay higher price for his customized product. Furthermore, the benefits of CAD/CAM systems can be exploited by experts having proper knowledge about their usage for designing and manufacturing.

In the present work, an attempt has been made to explore the possibilities to develop a technique of tool path generation to sculpture a 2D image on stone or on wooden board in look like 3D parameters with point cloud data. This image processing based paradigm will help the customers to create image expression in 3D aspects within the scope of 2D image provided, and help them overcome the burden of higher cost of CAD/CAM system by making this technique. The 2D image provided by the customer can be used in the same manner for creation of NC tool path data, which can be further used with any three-axis vertical milling machine to create/realize the final product.

1.1 CONCEPT OF TRANSLATION OF 2-D IMAGE TO 3-D FEATURES.

Computer-aided design (CAD) is the use of computer systems to support in the creation of products, alteration of pre-planned parts, study or optimization of a design. CAD software has been used extensively round the worlds to increase the productivity of designer, improve the value of design, and improves interactions through certification and to create a design and manufacturing database for future reference. CAD output is often in the form of electronic files or electronic media for printing, machining or other manufacturing operations [8]. This also involves for the creation of computer models or products as defined by the geometrical parameters [1], [26]. CAD systems allow designers to sight or define objects under a wide range of imaginary or parameters and to test these objects by simulating real-world conditions on it.

In the concept of translation of the 2D image to look alike 3D object is based on purely the image representation in which the pixel color intensity is measured with its particular grayscale value at that particular space. The image contains lots of data in term of the color and may be said that in the term of the color intensity. The cad system is joined in the manner that the automatically can get the information about the image and manipulate all the features in the manually or get the end result in the form of the look alike 3D part. The 3D cad models of the part can be saved into number of data formats that can be then translated into customized or commercial cam packages to generate the NC tool path data. This NC tool path data is used for machining of part out of raw stock using a CNC machine tool. Additionally, a number of input parameters like machine type, tool type, direction of machining, feed rate, speed of cut, required

surface finish, distance between machining passes, direction of axis, and operation dependent data (like threading, surface machining, or contoured machining) are required to be specified by the CNC machinist or CAM engineer in a CAM package to get the correct NC toolpath data. Thus translation of the CAD model to CAM package, and then entering the desired machining information needs an expert and takes a lot of time till the NC toolpath data is generated for customised 3-axis vertical milling machine [24].

Figure 1.1: Point cloud data of an image.

1.1.1 Image representation

In order to construct a look like 3 dimensional image model from the collection of 2dimensional image or a photograph, the intensity of color that is taken under consideration when a reg, green and blue pallet get together change in gray scale image. This intensity of the light of the image is

the source of experiment, modification so that can be converted to look like 3 dimensional. Repeated adjustment of point cloud data in which the z-axis is going to converted through noise removal technique. The main method that will be study in this paper is to get a noise removal from the image and the normalizing factor that should be balanced to get the precise image data points that should be look like 3 dimensional.. In 1^{st} there are about that data points to get the z-axis of the image or we can say the depth mapping of the image. In this paper we will discuss about an efficient method of conversion of 2D image photograph to the 3D image. RGB image is to be converted in the gray scale image and this will be in its range in (2^n-1). This gray scale image value of color intensity now be treated in the Gaussian noise removal or Gaussian smoothing done on this so the z-axis should be precisely accommodate within the range of the mean value of this. Then the particular axis can be normalized in the particular range which is demanded. The data points formed after this within the range of point data which on conversion of 3 dimensional we got the approximate to the input image with 3^{rd} dimension. This can also say that under the appropriate condition of image light intensity distribution it will give its best result. In this thesis a approach is given to convert a 2 dimensional image in look like 3 dimensional image object.

1.1.2 Digital image

Digital image is a numeric demonstration of a two-dimensional image. It is supporting on whether the image resolution is permanent, it may be any type that is of vector and raster type. That the "digital image" normally raster one and termed as bitmapped image. The image is defined normally on its pixel values. Which are to be in R, G and B values(Red, Green and blue). On an average people do maximum work on raster image of different kind landscape, grayscale scans of printed credentials, construction plans, panel shots, faxed documents, medicinal images such as x rays and ultrasounds, and multitude of others. The digital image is mainly used for different kind of work on different scale of use. In the image(1.2) shows the combining of the three color pallets of the main color of the screen and this with different color ratio changes to the different resultant color.

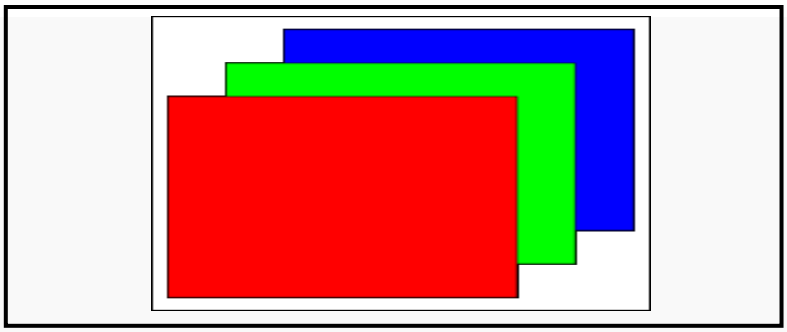


Figure 1.2: Separate R, G, and B image layers

1.1.3 Image size and resolution

In the following, we presume rectangular images, and while that is a comparatively safe assumption, exclusion exists. The size of the image is resolute directly from the lenght M (integer of columns) and the height N(integer of rows) of the image matrix I.

The motion of an image specify the spatial dimensions of the image in the real world and is given as the number of image fundamentals per measurement; for example, dots/inch (dpi) or lines/inch (lpi) for print creation, or in pixels per kilometer for outpost images. The motion of an image is the same in the level and upright directions because the picture elements are square.

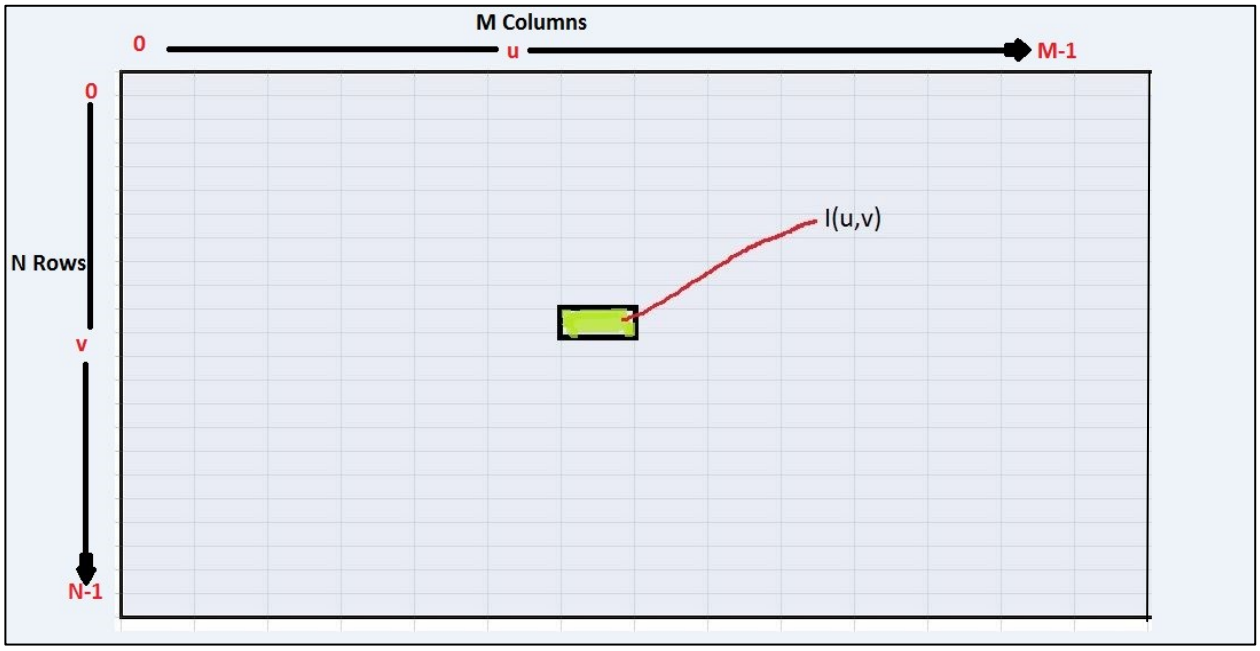


Figure 1.3: Image coordinates.

Pixel value here is the resul or the resultant color which is generated through the combination of the three main colors that is Red, Green and blue. Pixel value is integer value that is depend on the mainly the value of the pixel color ratio combining to generate them. There are 2K different values which depend on the pixel value.

Image coordinates system is the way in which to find the situation on the image correspond to which image elements, we need to inflict a coordinate system. Opposing to normal mathematical convention, in the image handing out the coordinate arrangement is flipped in the vertical track; that is , the y-coordinate have the top to bottom and the origin lies in the upper left. While this system has no improvement, and the fact it makes geometrical convert more complex to describe. The generation of this system is lies in TV electronics, where the image rows usually follow the direction of electronic ray, which stimulated from the top to the bottom of the monitor. The number of rows and columns at 0 for realistic reasons since in java array indexing begins at 0.

Table 1.1: Grayscale (Intensity Images)[12]

Chan	Bits/pixle	range	Use
1	1	0-1	Binary image
1	8	0-255	Universal photo
1	12	0-4095	High quality
1	14	0-16383	Professional
1	16	0-65535	Highest quality

Table 1.2: Color images[12]

Chan.	Bits/pixel	Range	Use
3	24	$[0……255]^3$	RGB, universal
3	36	$[0…….4095]^3$	RGB, high quality
3	42	$[0……16383]^3$	RGB, professional
4	32	$[0……255]^3$	CMYK, digital prepress

Eight bits per model (24 bits per pixel) seem sufficient for most cases, but faint banding models may still be noticeable in some smoothly unstable images, above all those subject to define. Mostly challenging applications may use 10 bits per sample and some much.[27]

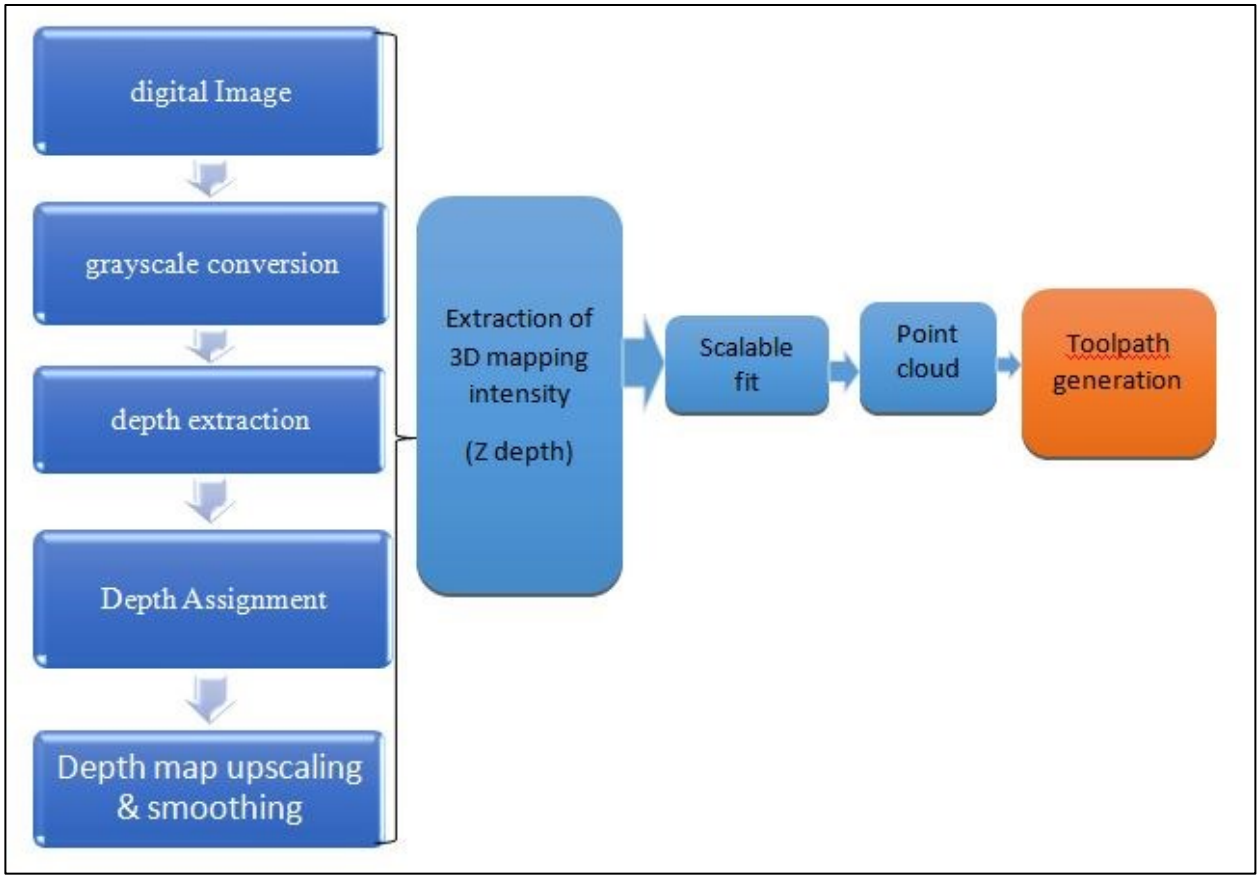


Figure 1.4: Overall procedure of 2D-to-3D media conversion

On the next side, some images which is taken under consideration will choose the 8 bit images which consist the range of 0 to 256 colors in it. This conversion consist of the dithering and yields for the fuzzy images. This depend on the main images with some facial expression and some stone manatee. [27]

Graphic card which support the 16 bits per pixel and consider it have about 65536 different colors. The resolution of the image seems to be good in the non professional uses, more about without dithering. [27]

1.1.4 Grayscale image conversion

A grayscale image is conversion of a digital image that is R,G and B values in single one value. This value can be used further different kind of parameters reading from the image. There is a image color scaling in the gray scale value where the image is converted in grayscale level of 0 to 255 range. O belongs to black color and the 255 range belongs to white color.

Grayscale imagery are discrete from one-bit black-and-white images, which in the perspective of computer imaging are such part of picture with only the two colors, black, and white (also called bi-level or binary images).Grayscale images have some shades consist of gray in it. Grayscale images are also called monochromatic, denote the existence of only one (mono) color (chrome).[13]

Grayscale image depend on the luminance of the color of the images produces in the image pixel data. The luminance of the image considered to be a scale of measurement on the electromagnetic scale and mapping the heights of the image embossment for the final result model of the image. [14]

1.1.5 Depth extraction

Depth extraction is exactly what it means. As an application developer, only give the information of 2D image to 3D height mapping. more often than not this equates to defining a coordinate mapping depth to generate the 3rd dimension for the image. It correspond to the 2D image pixel information.

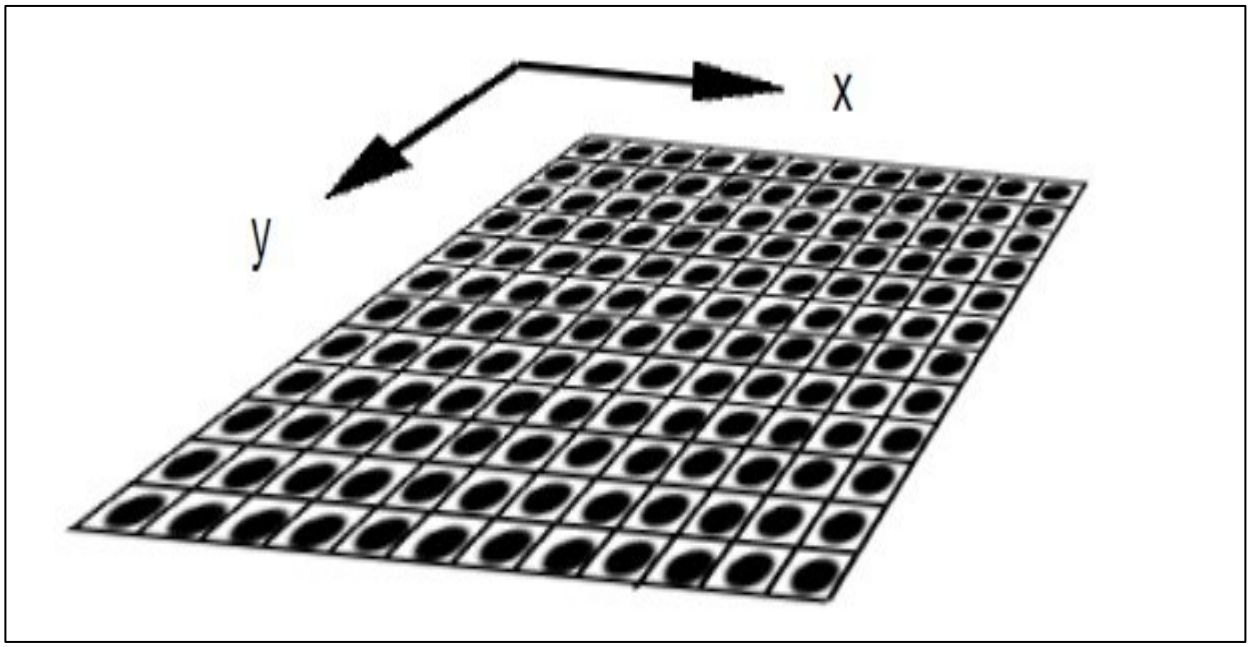


Figure 1.5: 2-dimensional distribution of image Points cloud

Now here we have to calculate the depth of the image features which is exactly calculated by the intensity of the image. The information within the optical sections along the z-axis can be used to reconstruct a 3-dimensional image.

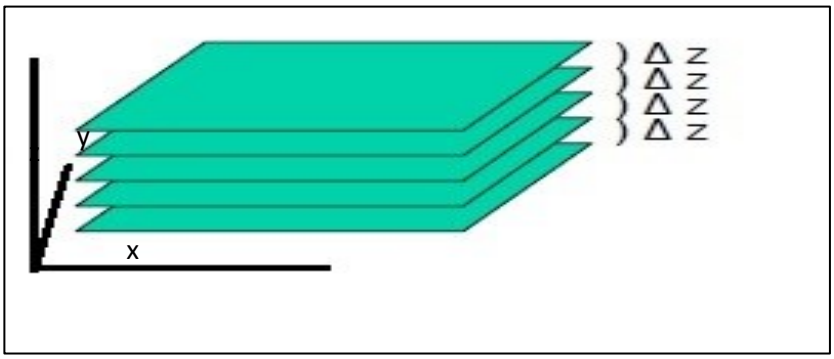


Figure 1.6: Extraction of the depth from grayscale image.

1.1.6 Depth assignment

The greatest variation between 2D and look alike 3D image is the intensity information. The lookalike 3D object jump out from the manufacturing slab or the work piece. The main work for integration of the depth information and intensity took together, it can built a strong foundation for making of lookalike 3D object to the finalized steps.

1.1.7 Depth map up scaling & smoothing

When a 2D image data calculated from the intensity of color the distribution of the image data is so disturbed so that it can't be drawn for the lookalike 3D object. For that the proper image depth assignment should be done for the lookalike 3D object so that the finalized work piece look proper in size and we can understand the depth which is properly distributed for the image. For that various noise reduction formulation has been done for the past work. Which is for the work in progress of lookalike 3D.

1.2 POINT CLOUD DATA BASED MODELING AND TOOL PATH PLANNING

In this point cloud data method we import an image data points. The point cloud data is in the form of the coordinates of the image parameters of the height and width and another the color intensity which got through the image intensity of color. Basically a point cloud is collection of points in the array form in which the stitching on these points a collective surface formed which is responsible for image making. The user will be presented with a list of options.

The computer aided NC toolpath planning is the key technology for today's manufacturing industries. The NC toolpath data for CNC machining of complicated parts or face sculpture like forming dies and creating the surface of some complex model used for sheet metal cannot be created manually because it contain precise value movements in any axis of the part. Thus for all complicated shapes to be machined in CNC machining centers, the reliable CAM packages has to be used, which means CAM package should be able to generate interference-free toolpath data. The toolpath consist of a series of gouge-free cutter location (CL) data. The CL data is then used in CAM post processor for creation of machine specific NC part program. Using web based applications, a new paradigm can be thought of where automated part modeling can be integrated with automated NC part program generation. Thus the total integrated CAD-CAM environment will save a lot of time as well as total cost to be incurred by the user.

1.3 WEB BASED APPLICATIONS

Today world is globally connected over internet. The internet uses allows the user to get any data or a application which he can run for the particular purpose. With this help of internet the world has became too small that information can be exchanged, processed and accessed between any number of terminals between remote locations. There has been big success and development of the "*World Wide Web*" (www). Today many algorithms with software are developed by using this web-based technology in different areas such as banking, e-commerce, education, government and entertainment. The information and database systems are being migrated to web environments in order to deploy their functionality over the web. Modern web-based application development has give us with the opportunity to save time, money and the way the companies/ services providers interact with their clients. The two main components of web based applications used for its proper functioning are this:

1. The unique features of the web use.
2. The operational environment of web applications.

The goals of the "www" project is to establish a shared information space through which the clients or customers can access the information from anywhere around the world. Using above advantages of web based application; an attempt has been made for designing a web based approach for exchange of data for integrated interactive look like 3D image modeling and NC toolpath generation.

1.4 Present work

The scope of this dissertation work is to create an interactive online web based enabled automated CAD designing system which allows the user to interactively create look alike 3-Dimensional object with user-defined parameters. This system can be integrated with the automatic toolpath generation system for developing a fully web-based automated CAD-CAM system. In the present work, an attempt has been made to explore the possibilities to develop a technique of toolpath generation to sculpture a 2D image on stone or on wooden board in lookalike 3D parameters through image. This image processing based paradigm will help the customers to create image expression in look like 3D aspects emboss within the scope of 2D image provided, and help them overcome the burden of higher cost of CAD/CAM system by making this technique. The 2D image provided by the customer can be used in the same manner for creation of NC tool path data, which can be further used with any three-axis vertical milling machine to create/realize the final product. Thus this approach can be thought as a step forward for web enabled integrated CAD-CAM environment.

CHAPTER 2
LITERATURE REVIEW

In this chapter, a literature relevant to the concept of image processing for 2D image conversion to look alike 3D data , noise reduction, NC toolpath generation for three axis vertical milling and various aspects those related to formulation of a 3D environment to create a parametric model, have been reviewed. The study of literature reviewed for present work has been divided in five main parts as given below:

1. Image processing for 2D image conversion to 3D data.
2. Noise reduction.
3. Depth mapping
4. Toolpath generation methods for point cloud data.
5. Web based NC tool path planning.

2.1 IMAGE PROCESSING FOR 2D IMAGE CONVERSION TO 3D DATA.

2D image to look alike 3D data is the process in which some parameters are to be under consideration for giving it a height relevant to the image color intensity. This is also called as 2D + z depth which is acquiring the current market developments.

Rockwood and Winget [1] create a 3D model from compilation of 2D images of an object. In this paper, intensity of the color defines it with respect to the energy factor or function of energy and corresponding articulated mesh in three dimensional space. Here given example of build models of departed celebrities from the film clip. The approach in this paper is to be computerized for complex 3D objects and sophisticated iiradiance function without the need of the attribute recognition.

Sneha and Sheela [2] give technique to construct 2D to 3D translation for images using hough transformation. In this technique the image is clean to reduce the noise substance. This way works on periphery images obtained by producing the canny edge algorithm to the source image.

Jonathan B. Glass [3] construct a model by evaluating the upper threshold and lower threshold of the color images range, that will be extracting to find the depth map of the image. A custom mathematical model is applied to the points of the range resettlement for the images to 3D model.

Gang Zang et al. [4] construct a theory of precise and scalable surface demonstration and restoration from images. It produces a new surface demonstration method, called patchwork. It increases 3D surface restoration capabilities from manifold images. In this loom it propose two applications that exhibit how this method noticeably extend a 2D image to 3 dimension. Some minimum cut methods have difficult in handling complex shapes. Its reconstruction using the propagation approach to create a surface outlook of a image with input as a image or 3 dimensional points.

2.2 NOISE REDUCTION

Ville et al. [5] construct a method of noise reduction of the fussy images which are corrupted by additive noise. This filtration consists of two stages edge detect filtering, downy image filtering clatter decrease. Downy rules are fired to regard as every direction about the processed pixel. Additionally, the profile of the connection functions is personalized according to the residual amount of noise after each iteration.

Bai et al. [6] construct a mathematical model to apply the edge detection for noisy image. Gaussian noise removal method have its advantages in creating a non noisy image from the gray scale images and also binary images.

Yang et al [7] construct a depth map generation using local depth hypothesis in which it states that the 2D image does not contain the depth information, an infinite number of 3 dimensional points are projected to the some plane. Using a hypothesis of depth variation can reduce the human effort to generate a depth map.

2.3 DEPTH MAPPING

Savarese et al [8] gives two new method for extracting the three dimensional shape of the image which is exposed on it. In these methods only white and black part of the image is under consideration for mapping.

Nick Pears et al [9] have give a method pose normalized depth maps from 3 dimensional point cloud data. It both of aligned or pose normalized deepness maps from noisy point cloud in a moderately unobstructed poses. This system mainly contains four stages: (i) data filtering, (ii) sub vertex localization, (iii) computation of relative face orientation, (iv) generation of pose aligned or a pose normalized depth map.

2.4 TOOL PATH GENERATION METHOD FOR POINT CLOUD DATA.

Jasra [10] in the thesis it discuss about the tool path for the ball end mill on for the round pattern or on the round surface. It gives a approach of ball drop method for the tool path generation. Comparing the optimized tool path with the tool path generated , it has been seen that the present tool path that has been discussed is give closest result with th side feed and depth of cut for the radius of roughing and finishing passes can also be modified which cannot done.

Mehra et al. [11] have given a idea of visibility of noisy point cloud data. Gives a vigorous algorithm for calculating visibility from a given perspective for a point set containing concavities, non uniformly spaced samples, and possibly corrupted with noise.

Teng et al [12] presents a method for creating well-organized three axis ball end milling tool path directly from the point cloud data. This principal objective is to realize high competence in the machining area. The high effectiveness is attained by fragmenting the entire machining province into discrete areas according to the numerical complexity of the data points and by using cutter of unlike sizes for the unlike machining areas. The slighter and gauge free ball end mill cutter for the secluded composite machining quarter is subsequently selected from ordinary viable cutter series.

Fabio [13] gives a theory of reform of defined surfaces from randomly distributed point clouds derivative from laser scanner data or photogrammetric image capacity is a very hard problem, not completely solved and problematic in case of uncompleted noisy and spaced data.

Huang et al [14] introduce medicinal draft as a arch draft representation for three dimensional PCD. This make a key observation in adapting median nearby to peak set in lieu of a three dimensional shape gives increase to a 1D configuration.

Davalli et al [15] presents a solution for the automated texturing of models obtained from 3D scanners by using uncelebrated pictures taken with a digital cameras. The proposed method have a calibrated light intensity images given by the scanning devices to automatically get the 3 dimensional point cloud data.

2.5 WEB-BASED NC TOOLPATH GENERATION METHODS.

Ahn et al [16] presented a macro machining examine (MIMS) have the world wide web technology. A 3D geometry created from a profitable CAD system is generated as an STL (Stereo Lithography) format and the method limits for 3-axis CNC vertical milling are to be elected via the user interface. This also generate a feedback form for the generated format of the file from the user. And this is the main type in which the user form feedback got stereo lithography based cam module.

Adamczyk And Kociolek [17] discussed about the folders as user and server applications on the world wide web are a great commercial and point of view solution. This technology is based on KSP-OSN/WIN distributed environment system which in recieve introduce to different language announcement fashioned repeatedly in the environment. resolution of the web memory for KSPOSN structure is mostly exciting for down cost CAM structures like KSP-OSN/WIN system. This full system changes the cost that is reduced by this system and the residual memory got through this will be same for the solution.

Bangotra [18] discussed about the toolpath generation through web based system. This system basically works on the MACRO profiles on solid works collaborated with this system. In the thesis the main highlighted part is the work is to create the online system for the toolpath generation of the different artistic design.

2.6 CONCLUSION OF LITERATURE REVIEW

In the above literature, a brief discussing of papers has been studied with the aim that how customized solutions for web based are available over internet, which includes a mixed real time environment for collaborative product design and development has been discussed. A 2 dimensional image to 3 dimensional approach, which is not a history-based method of CAD model, toolpath generation also has been discussed which can be further used as to automate the CAD designs. So, a thought has been purposed to develop an environment that implement the

strategies of the above discussion to develop a web-based application for creation of 3Dimensional model and NC toolpath generation.

CHAPTER 3
METHODOLOGY

The work for converting a 2D image to look alike 3D contains different steps of fiding the all aspects of image parameters in regards of its height and length and color intensity. A computer program should have been created in the java can be used for generation of look alike 3D design elements for creating 3D design when input is a image. The following section describe the details of the web based system used and the program run on java to find out the intensity and the pixel points data to generate the 3D point cloud data. To create the designed image pattern , in the present work mathematical and program algorithms for lookalike 3D design elements has been discussed for the creation of the 3D tool path generation for wood sculpture image using 2D image as a input and that system should be web based application. The strategies for develop the present work include the following different components which has been discussed below.

1) Design automation of the image normalization and scalability.
2) Integration of tool path algorithms with design automation.
3) Web based implementation of integrated design and NC toolpath algorithms.

3.1 NETBEANS INTEGRATED DEVELOPMENT ENVIRONMENT (IDE)

NetBeans integrated development environment (IDE) is used for emergent with Java languages but, this platform can also be used for other languages like PHP, C/C++, Java Script, CSS and HTML. NetBeans IDE is depended on Java that can be run on Windows, MAC and Linux Solaris and other platforms supporting a compatible JVM [33]. It is a free and open source and has a large community of user and developers around the world. It is a absolute and open-source integrated development environment. NetBeans podium allows applications to be residential from a set of modular software mechanism called modules.

3.1.1 Integrated modules

These are three types of integrated modules are part of the NetBeans IDE.

· NetBeans Profiler.

· GUI design Tool.

· NetBeans JavaScript Editor.

3.1.2. Programming language for web development

The indoctrination language for web development are those languages which can be use to make an interface for developing a World Wide Web based applications. In today's world, there are many programming languages which are available to web developers for making a web design. The most popular programming language for web developments are Java/Servlet/JSP, HTML, PHP, C++ and ASP etc. There is no perfect programming language available for the web development.

Following are the some of the important aspects, which has been considered while selecting a programmable language for web development.

1 Server platform.

2 The server software running.

3 Budget.

4 Previous experience in programming.

5 The database to be chosen in the backend.

3.2 IMAGE RGB TO GRAYSCALE

2D to 3D image conversion system supply valuable information that can be used to automate the manipulation of the objects. The first main task which is to convert the image in the look alike 3D is the convert R,G and B value to singular value which is the combination of the some

3.2.1 Suitable image

RGB color patterns consist of the mainly three colors which are Red, Green and Blue. This pattern is widely used for the main electronic devices and another television sets and computers. This is the main reason of all main colors required and with combination represents the internal resultant color of all pictures. The main type is to find the suitable image. RGB image taken through digital camera with good lightning effect can be treated as the good picture to handle further. All programming languages taken under consideration depend on this color pattern.

The image coordinates starts with the raster image representation starts at left top end of the computer.

Figure 3.1: raster image axis representation.

Here the representation of the image coordinates for reading a image with computer language. In which the x coordinate starts with upper left corner of the computer to right side and y coordinates starts with upper right corner to lower end. This is the way in which the computer reads the image data. All electronic devices read the image data in the same aspects. This is the representation of raster image with axis representation.

RGB is the additive color scheme, which means that the all color start with black and are created by adding the primary colors. This is like a imagine a dark room where it spread of 3 color beam is overlay- one Red, Green and Blue on a sheet of white paper.the RGB color coordinate can be considered as the three dimensional space which is taken as the three another coordinates of the space. RGB is a very simple color system, in below we image() this is shown that the Red, Green and Blue images differently, how they are differentiated. Gray scale image data in mid of the box represented in 3D box. But this can be readjusted with some weightage factor for the convenience of the image data interpreter.

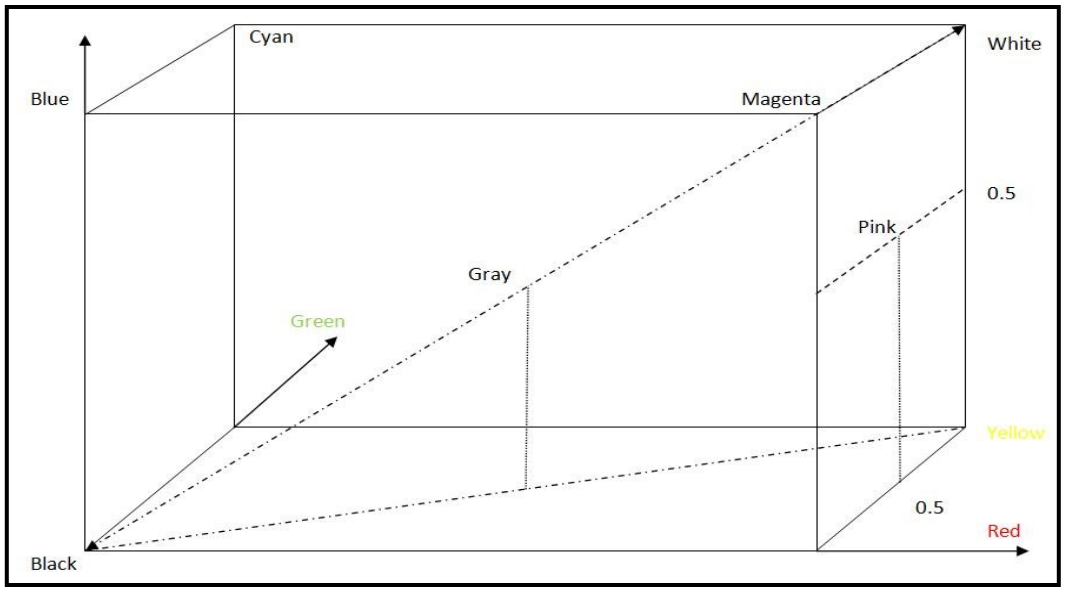


Figure 3.2: Representation of RGB color space.

Table 3.1: RGB value corresponding to different colors.

Color	R	G	B
Black	0.00	0.00	0.00
Red	1.00	0.00	0.00
Yellow	1.00	1.00	0.00
Green	0.00	1.00	0.00
Cyan	0.00	1.00	1.00
Blue	0.00	0.00	1.00
Magenta	1.00	0.00	1.00
White	1.00	1.00	1.00
50% gray	0.50	0.50	0.50

Given different values for the image and getting the different image color mapping got by this implementation. If only Red value factor given to the image transformation means (R=0.5, G=0.0, B=0.0)and for only green value (R=0.0, G=0.5, B=0.0) and finally (R=0.0, G=0.0, B=0.5). the different results for image factor got through this implementation.

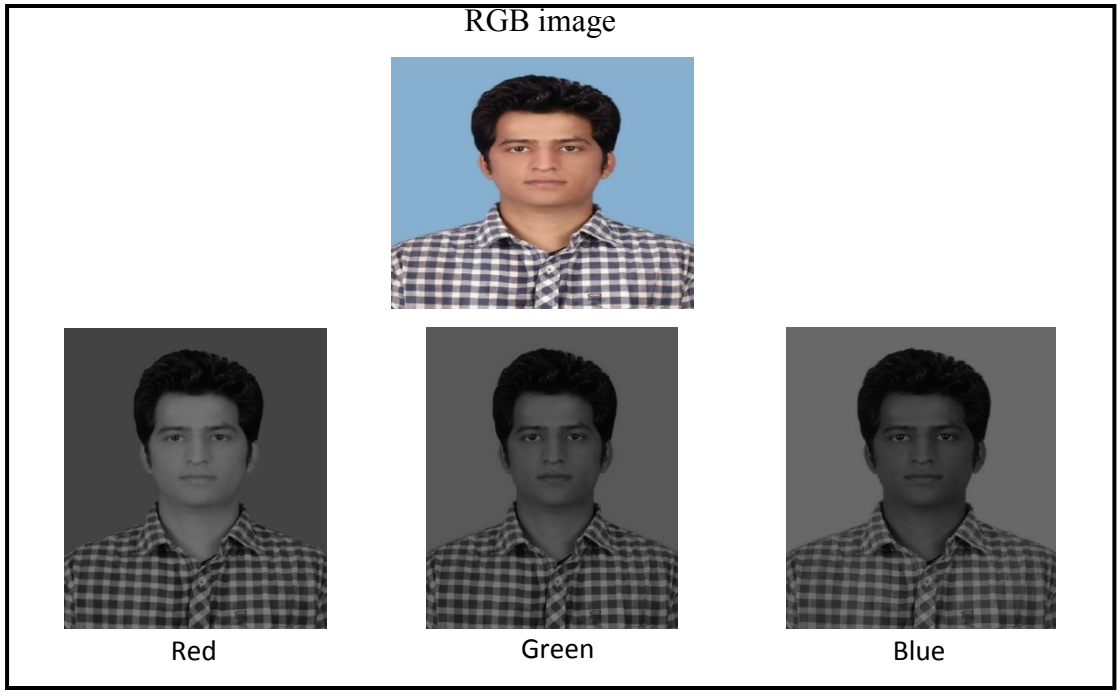


Figure 3.3: RGB in different form.

3.2.2 Conversion to grayscale

The RGB color image is converted to gray scale image by computing the equivalent gray scale and the intesity of the color image for each of pixel. This is reprensented by the Y for each of the pixel. Simply it can be, Y could be computed as the average:

$$Y = Avg(R, G, b) = \frac{R + G + B}{3}$$

Here avarage of the three color R, G and B color has been taken. The combinaion of color red and blue is more darker and the red and green is more luminance in the image so the particular weightage should be given to the particular image color and a resutant image with good luminance got through this.

$$Y = Lum(R, G, B) = wR.R + wG.G + wB.B$$

For the practical work in computing the image with luminant grayscale color the weightage which is selected for this.

$w_R = 0.299$, $w_G = 0.587$, $w_B = 0.114$

Java program is used to be translate a RGB image to gray scale image. Netbeans uses the same way to convert the RGB image to grayscale image. With the plus of these three different images the main outpu is the grayscale image.

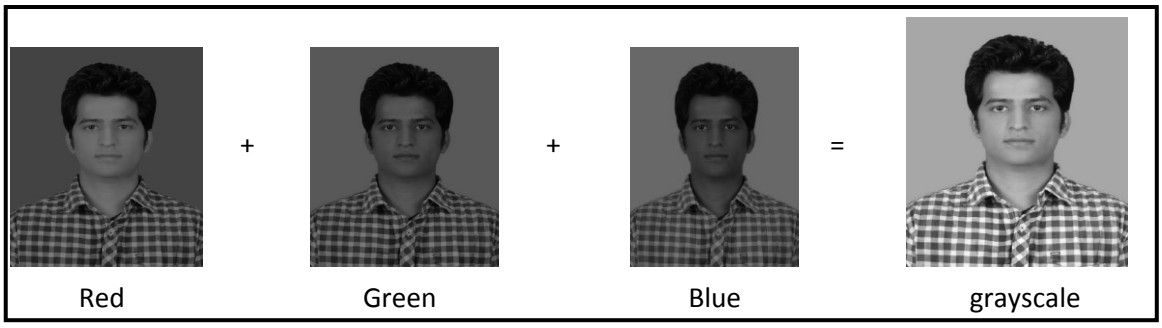


Figure 3.5: (R+G+B)/2 factor create a grayscale image

Here the result are given for witch we are try to compare the image results for the 3D.

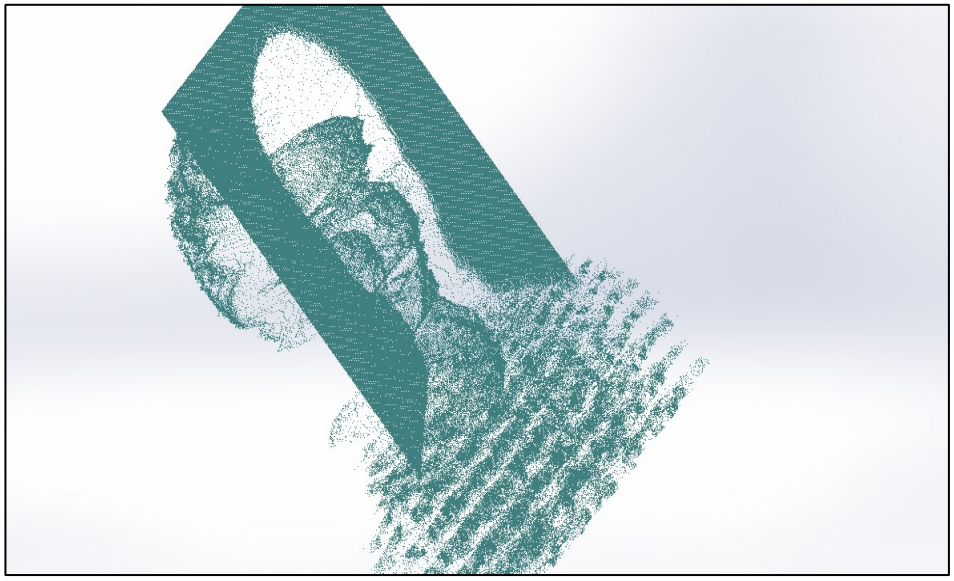


Figure 3.6: Grayscale image point distribution in 3D.

First he image data got through this implimentation is not in proper ration devided in so that the in image data the hair portion which is black is very disturbed so that the hair region only goes to very lowe position in the point cloud data. So that to arrange this data in the proper ratio some thery of the mathe matical should be implimented on the current method. Readujust

3.3 READJUSTING POINTS IN LOOK ALIKE 3D

The data got through the grayscale method color intensity is not in proper way so that can be used for tool path planning and getting the last object of machining. So that a proper mathematical implimentation should be done in a way so that the last image data got through the mathematical implimentation should be in proper way oriented in 3D space.

3.3.1 Differentiation Based on Brightness

This method includes determining a brightness "threshold" on a gray scale image such that everything above or below that value is the object of interest (i.e. light objects on a dark background or vice versa). Most commonly this is a value between 0 and 255 corresponding to the 256 levels available in 8 bit coding for each pixel. The threshold value may be fixed, or it may adapt to varying light levels via a simple (average gray level) or complex algorithm. The threshold is applied to the image, separating the object(s) of interest.

3.3.2 Differentiation based on color

Color is best addressed by transforming each pixel of the image to "distance" from the trained color sample set in 3-axis color space. Color representation methods usually characterize a color by 3 coefficients. RGB (Red, Green, Blue) is common and native to most imaging and display processes. Triplets of coefficients require a three dimensional graph called a "color space." R, G, B are each located on an axis orthogonal to each other, for example. "Distance" between the points representing two colors in this space is the three dimensional Pythagorean distance ($[(R_1 - R_2)^2 + (G_1 - G_2)^2 + (B_1 - B_2)^2]^{.5}$) between them. The "trained color" can be that of either the desired object or the background.

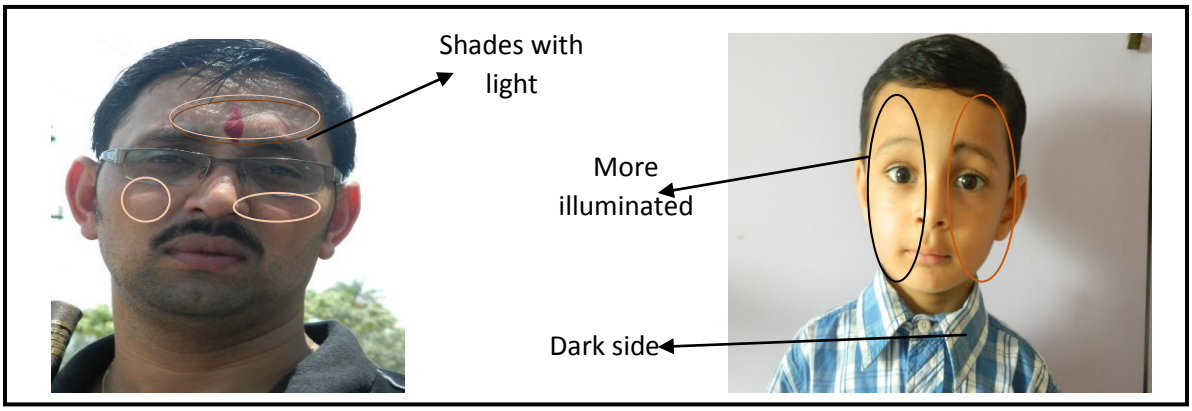


Figure 3.7: Image noises produced when captured.

3.4 NOISES IN IMAGES

The principle source of noise which is produced in the image is in the time of acquisition of the image or capturing the image from the electronic media. There are many sources of cause of noise in the image that is due to bad lighting and shades which fall on the images are not so

much adjusted properly in tha 3D parameters and the results are not accurate. Gaussian noise can be reduced these noises with the spatial parameters and make the Z axes accurate so that can be got properly.

Image result with the bad lightning or making some illuminated region will give the wrong distribution of the image and also can't be readjusted with these algorithms. So capturing image data should in proper lightning and no shades should be produced so that can get the accurate results.

Figure 3.8: properly illuminated images with no shades.

Through smoothening the noises of the only right image or proper image data get the accurate results for the image value which only depends on both illumination and color factor equally

3.5 NOISE REDUCTION IN IMAGES DATA

Noise reduction is procedure of removing or minimizing the noise from the image. Images taken from the digital cameras and the normal cameras , at the time of acquisition of the image it capture some noise from the surrounding environment. So this noise or the upper and lower thresh hold data from the image data should be normalized and properly distributed so that the noise can be removed from the image cauterization.

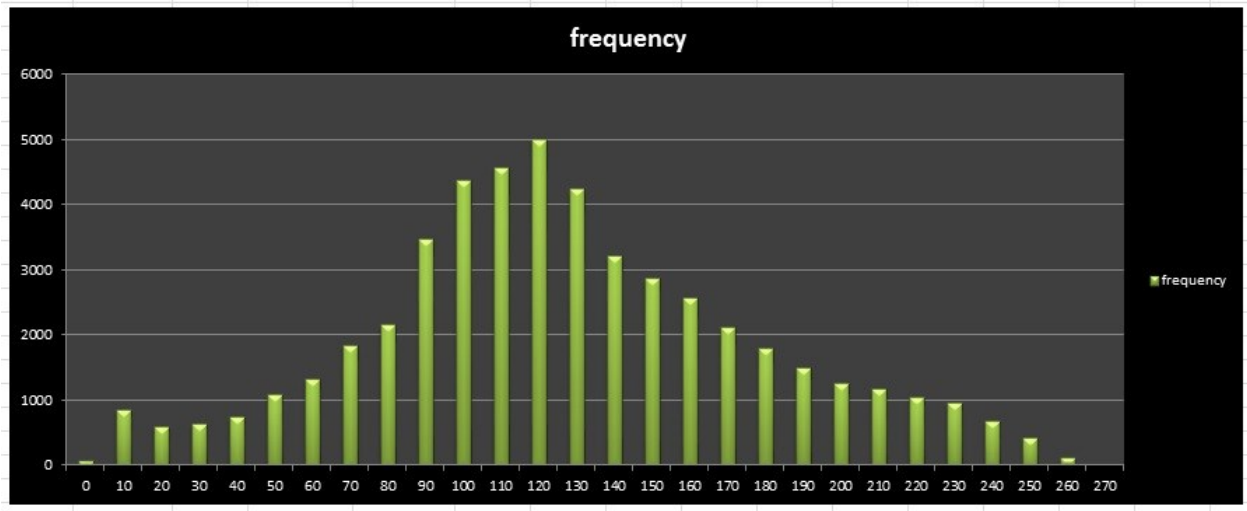


Figure 3.9: Gaussian Data Frequency Distribution.

Here the image intensity is considered as the energy factor of the image and in which it should be minimize or the energy factor is rendered in such a way that the image errors can be reduced or the image can be fitted in the relative imaginary scale so that the all the point cloud data should be in one equilibrium pattern.

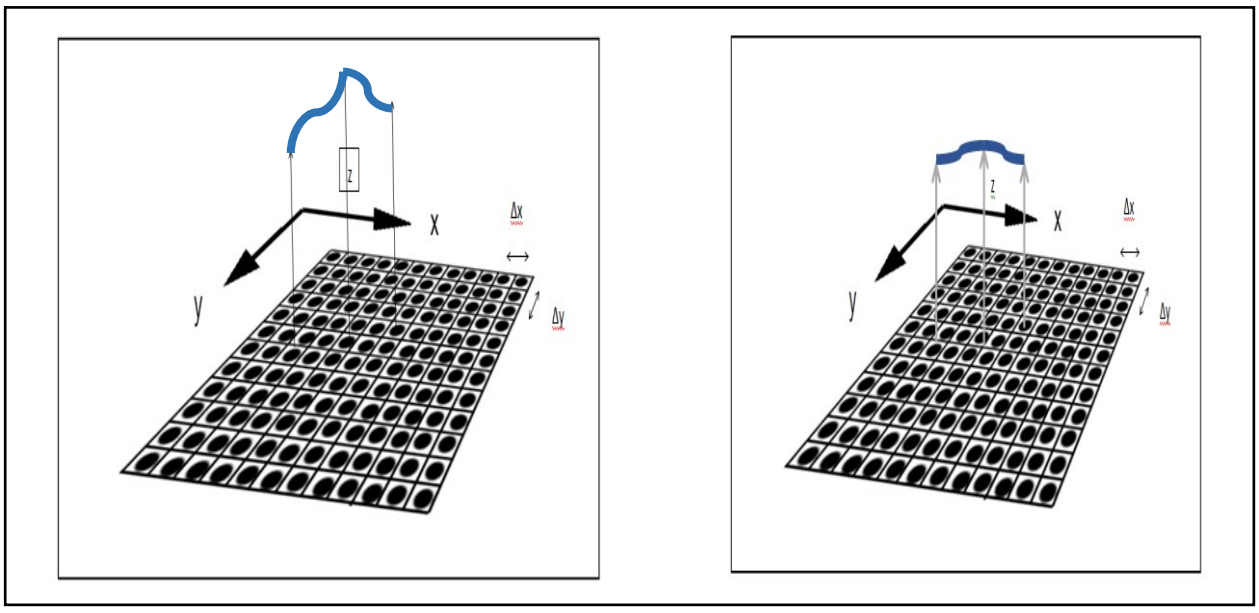


Figure 3.10: Gaussian Noise Rendering Z(color map intensity)

Gaussian noise represents arithmetical noise having the probability density function (PDF) and having that of the called as normal distribution, which is also known as the Gaussian distribution.[26] in same words, the values of the Z is distributed with mean and standard

deviation to a particular Gaussian distributed. The probability density function of a Gaussian random variable is given by:

$$P_g = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(z-\mu)^2}{2\sigma^2}}$$

where z represents the grey scale level, $\boldsymbol{\mu}$ the mean value and $\boldsymbol{\sigma}$ the standard deviation.

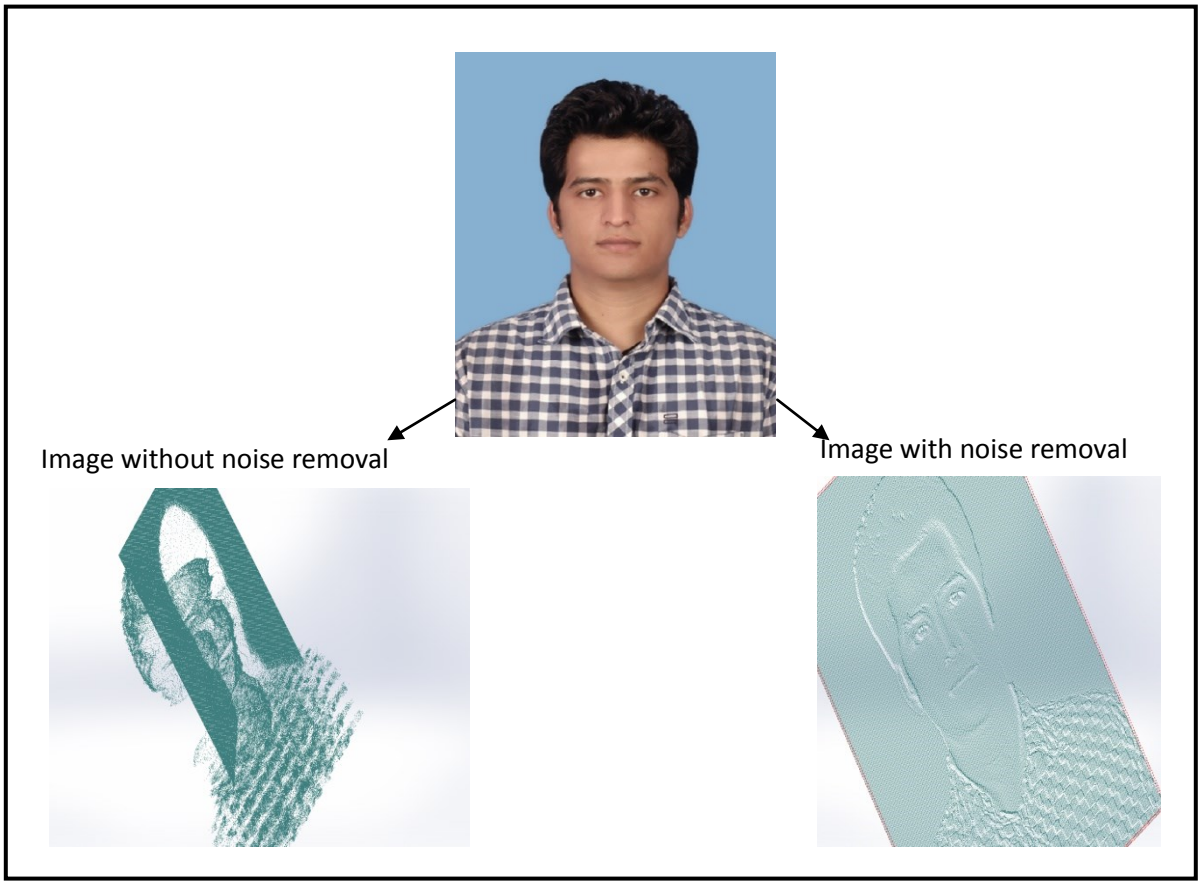


Figure 3.11: Noise Removal Effect on an Image.

3.6 NORMALIZATION

In mathematical approach and applications of the mathematics, normalization means the range of the parameters for which the sample must be adjusted according to user defined. In the simplest cases of, normalization of ratings means adjusting values measured on the different scales to a notionally common scale, often prior to the averaging. In more complicated way it resemble to the probability of the data which is nearer to one another in value and also the normal probability

have this type of range distribusion. In this part this a different approach in which a sample data had to be redistributed in a homogeneous pattern so that final result should be in the adjustable range of user defined.

Normalization transforms an n-dimensional grayscale image $I:\{X \subseteq R^n\}$-----$\{min,\ldots,\ldots,\ldots max\}$ with intensity values in the range (Min,Max), into a new image $I_n:\{X \subseteq R^n\}$-----$\{new\ min,\ldots,\ldots,\ldots new\ max\}$ with intensities color values in the range (newMin, newMax).

$$\mathbf{I_n}=(\boldsymbol{I-min})\times\frac{\boldsymbol{new\ max-new\ min}}{\boldsymbol{max-min}}+\boldsymbol{new\ min}$$

Where Z is the normalized or the scaled value for which we have to define the parameters below:

$\mathbf{I_n}$= normalized value.

I= each correspondent color value for each pixel.

Max= maximum value for whole pixel data (max color value).

Min= minimum value for whole pixel data (min color value).

New max= maximum value that should be given for scaling.

New min= minimum value that should be given for scaling.

In this type of Gray scale image data that have a range from 50 to 120 and we want to change that range from 0 to 255 range or it may be smaller in range that 0 to 1 or 0 to 2.5 or 0 to 5 or 0 to 5. This depend upon the 'new max' and the 'new min' value of the equation.

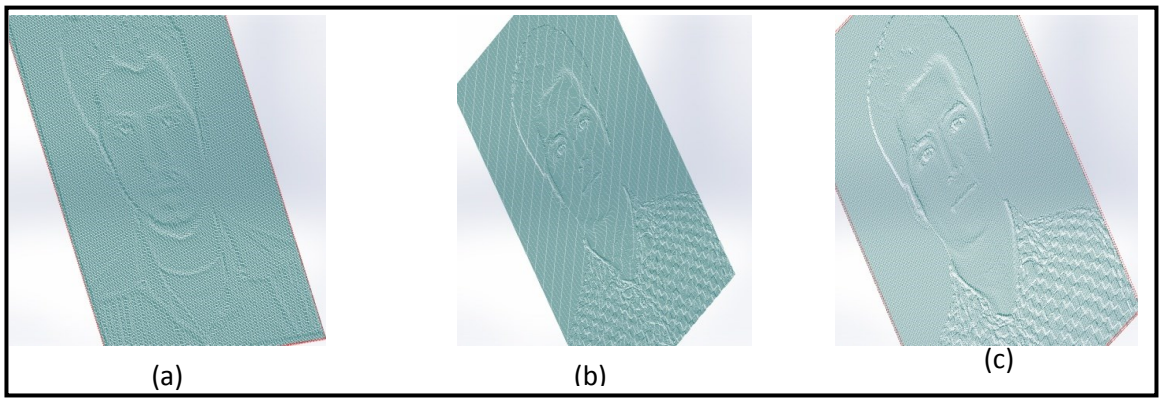


Figure 3.12: (a)Z range lie between 0 to 1(b)range lie between 0 to 2.5(c)range lie between 0 to 10

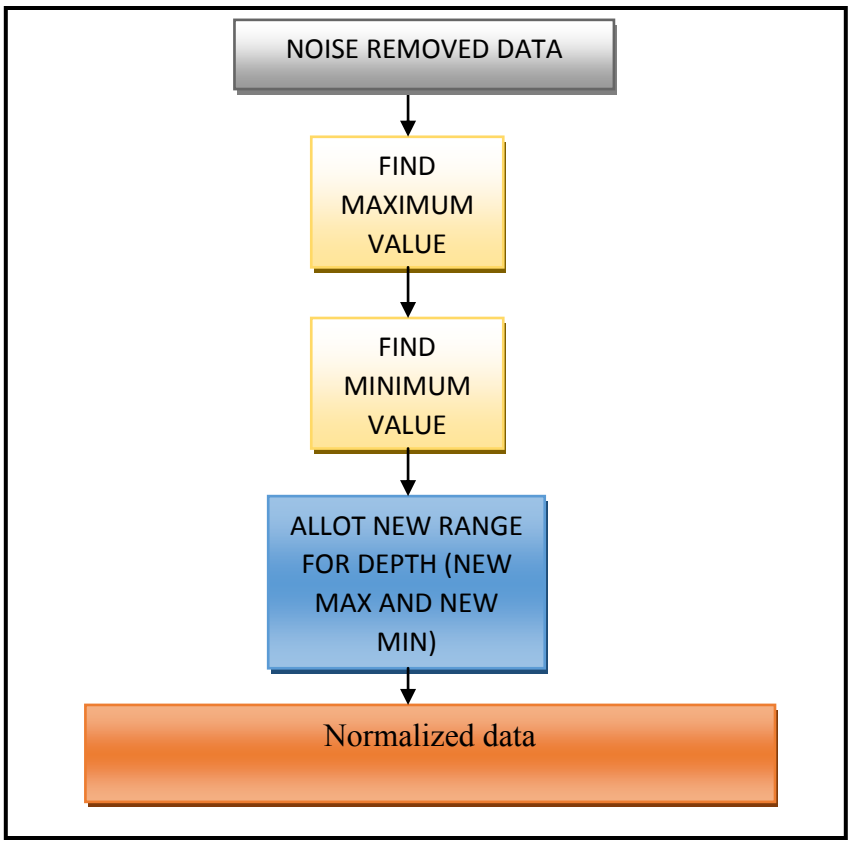


Figure 3.13: Normalization Flow Chart.

3.7 Approach for conversion of 2D image to LOOK ALIKE 3D

The web based integrated system for conversion of the 2 dimensional image to look alike 3 dimensional object follow steps in which the whole process of the image to 3D approach discussed. In the initial step of the paradigm the input image as a RGB form converted to the grayscale image. Now the gray scale image have only three parameters contains in it X, Y and intensity of the color(which is taken as the depth for the image). But the data which is generated as the intensity of the color or considered as the Z axis have a very noisy output. To eliminate or accommodate that noise in the image data, Gaussian noise removal formula has been in use for the homogeneous point distribution in the whole array of the image. The Gaussian noise formula makes the image more approachable in the depth map so that the gives the accurate image result for noise removal data.

Now the homogeneous range of the Gaussian noise removal data has been go through the scaling factor which is applicable for the image depth in which the 3 Dimensional data has to be raised upto a particular range that is from 0 to H_{max}. Now the point cloud data for operating for the tool

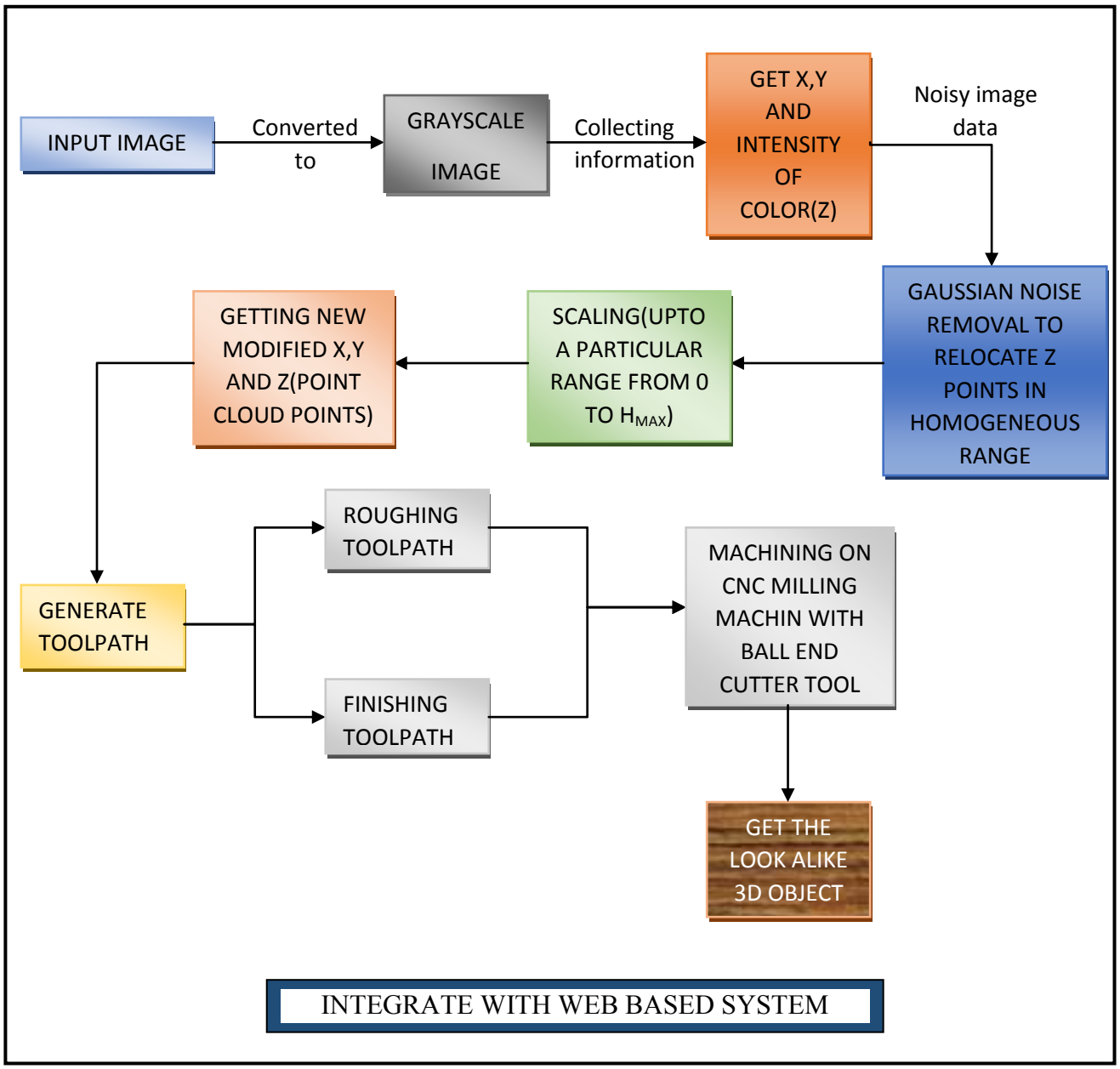


Figure 3.14: Approach for web based look alike 3D model

toolpath has been created which have a homogeneous range of the image depth map scaling. This point cloud data finally be operated for the tool path generation. There are two type of toolpath techniques contour toolpath and raster toolpath. Here in the this method the raster technique will

be followed. Finally the CNC milling machine to operate that toolpath for the roughing and finishing of the final object which is look alike 3D.

3.8 ALGORITHM FOR NC TOOLPATH PLANNING

An algorithms has been used for the calculation and computation of the toolpath from STL file which has been saved in particular format as discussed above. These algorithms convert the CAD modeler information as STL file into machine understandable format which toolpath file in text format. These algorithm are already been developed previously in C++ and Java platform. So, in the present work an implemented of these algorithms has been embedded within the developed web-based application environment [25] [27]. The following are the two algorithms which are used as given below.

1. Raster toolpath algorithm.
2. Contour toolpath algorithm.

3.9.1 Raster Toolpath Algorithm

The raster based toolpath generation algorithm from point cloud data models is a unique and faster development, which is useful in the rapid prototyping and computer-aided machining [25] and figure 4.14 show the raster toolpath.

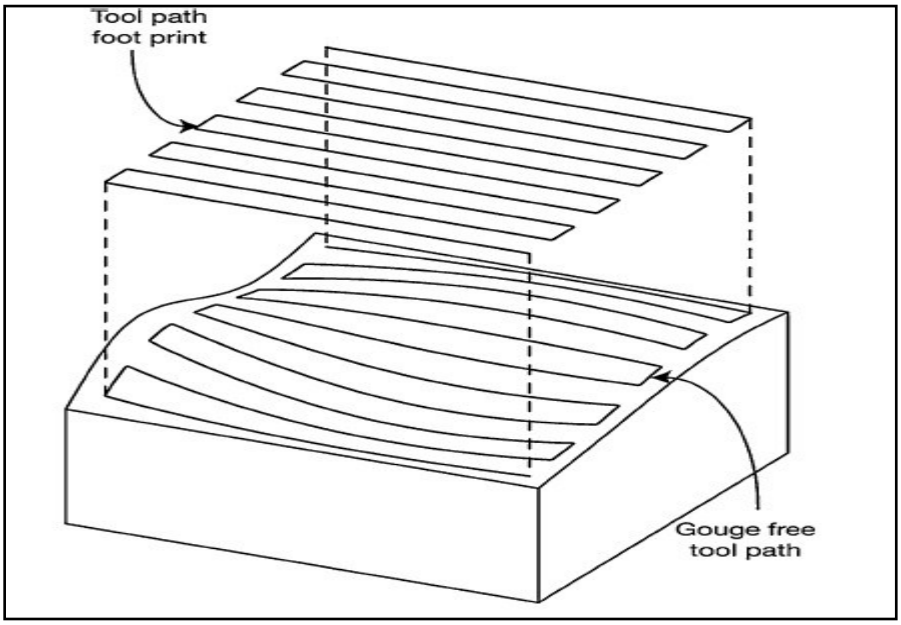


Figure 3.15: Raster NC Toolpath [26]

The data collected by image is so dense so that there is no further need of making stl or triangular check for the surface generation. Now the tool cutter location and cutter position should be get through the algorithm. In the image data we have pixel values a parameters of consideration so the gap between these points are very less or very dense data not require any type of stl generation for vertex check or surface check.

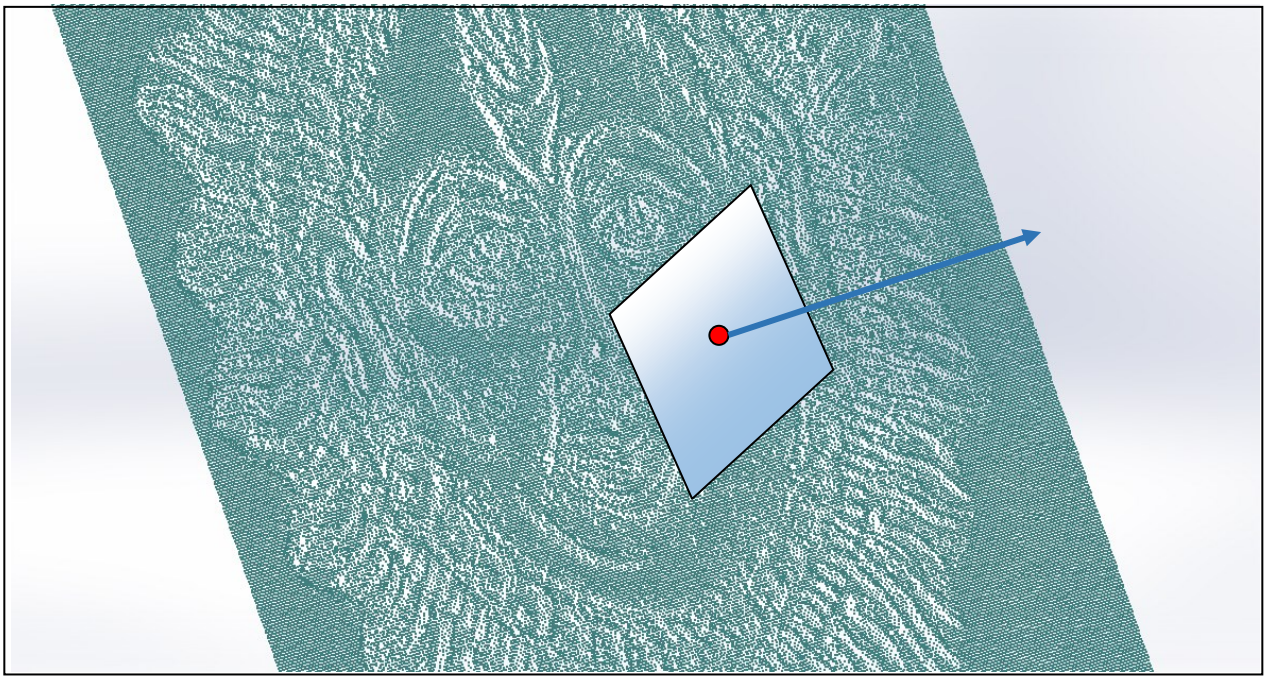


Figure 3.16: Surface normal to each point.

The generic ball end mill cutter of varying radius for roughing and finishing cycles can be used for generating of sculpture surface. The NC tool path planning strategy for NC milling machine has been discussed in this section in detail. For milling machine there are some parameters

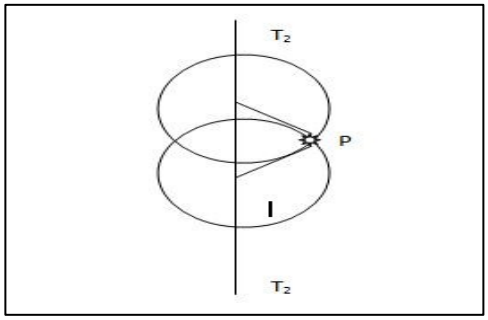


Figure 3.17: Toolpath strategy.

Here in the toolpath planning there are mainly feed forward step values and the side step value. The mainly feed forward step value is 0.2 of the radius of roughing tool uses for the purpose of cutting and for the side step value its 0.4 of the radius of roughing tool. And for the finishing side it will be 0.15 of the radius of finishing tool for the both of the cases of feed forward step value and side step value.

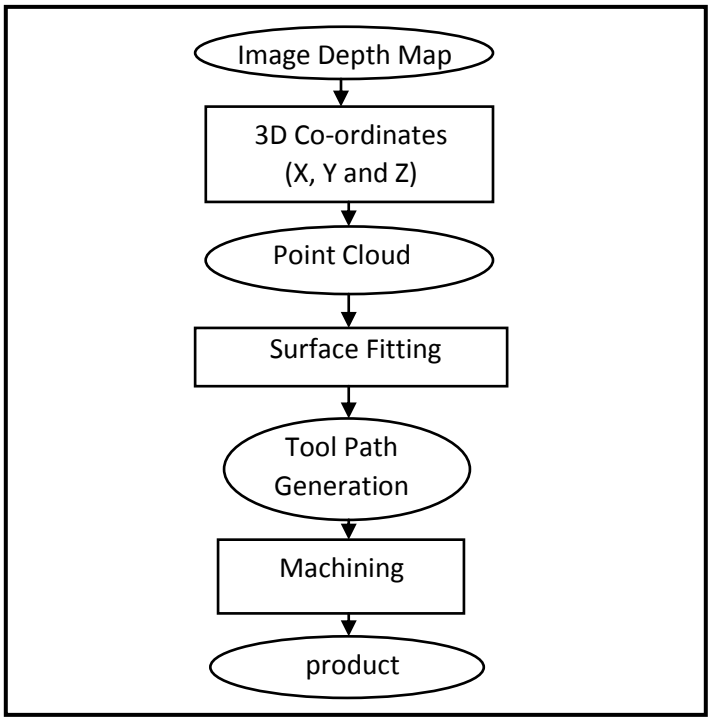


Figure 3.18: Flow Chart of Toolpath for Final Object.

CHAPTER 4
IMPLEMENTATION: WEB TECHNOLOGY DEVELOPMENT

4.1 WEB BASED APPLICATION DEVELOPMENT IN NETBEANS

The development of web based application in NetBeans is totally a Java based programming, which further uses some programming languages such as JavaScript, HTML and JSP for the completion of the fully operated web based application. This can also use outer database for storing or collecting the data. This web based application can be easily accessed or handled by any distant located client who belongs to anywhere in this world. He can approach only to internet or can get the final result machining toolpath files. As we already discussed how image point cloud data programmable environment can be used to generate look alike 3D for modelling. In this thesis report, we have created a web based application which can access these set of information automatically and give us the result tool path remotely. This is a method to invoke the image point cloud data within the data server by using an web based application through a website, which works on the client and server technology. Client can access this web based application over the internet or intranet through website.

4.2 ARCHITECTURE OF LOOK ALIKE 3D

The architecture of the web application is totally based on the server and client collaborative environment. It is a runtime user interactive environment that the client to interact with the server. The Figure 4.1 shows the interactive environment for the application. The Figure 4.1 gives a platform for the interactive environment to the web based modeling environment. The application developed in web environment was programmed to connect to the server algorithms that ran the software in the background to model the point cloud data model and provided an output to the client to the web browser. At client side the interface working is totally based on JavaScript and JSP (Java Servlet Pages) at the run time and further, is connected with the server side by using Java Servlet as shown in the figure 4.2. At server side, the interface had a totally collaborative environment that works simultaneously both with wamp server and database by using data connector.

At the runtime, the client interface act as a modeling design form for features where user can defined the model parameters. As soon as the client submit the filled design form, the user

defined parameters passed on to the tool path data file for the designing purpose through text file(PARAMETERDATA.txt) database connectivity.

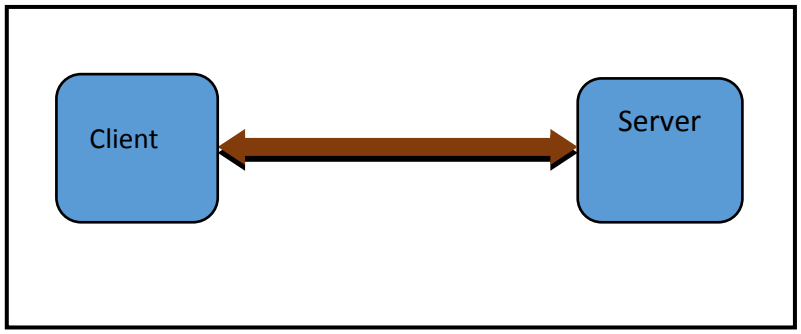


Figure 4.1: Interactive environment.

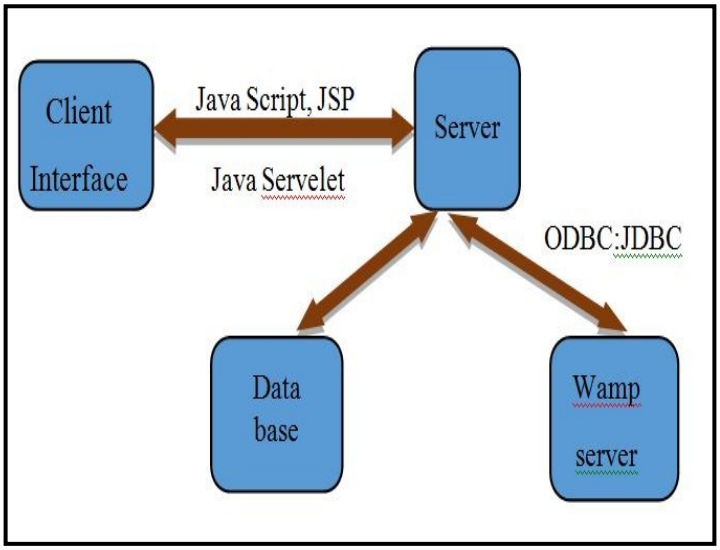


Figure 4.2: Architecture of Look Alike 3D

4.3 DEVELOPMENT OF WEB BASED LOOK ALIKE 3D DESIGN

The aim of the developed system has to allow the embossment of feature of 2D Image using this paradigm and interactive web based interface. Look alike 3D models are of different shapes, size and can be of different Images based on their canvas size.

4.4 COMPONENTS OF LOOK ALIKE 3D

The development of the look alike 3D web based application is based on different modules. The main modules is the Look alike 3D creation and display of the tool path file in the web browser using data transfer between client and server and generation of 3D solid modeller.5.4.1 Creation

and display of look alike 3D design As discussed in previous chapter 3, the look alike 3D designs are created using mathematical algorithms. The web based application provides the user a detail definition about design parameters, which are to be defined by the user itself. In the chapter 2, discussion has been performed to find out the best suited method for implementing the web based technology. It has been concluded that Java platform [26] would be the top choice. Java has a simple programming structures and is an open source language making it an ideal option for building the web-interface. For creating a web based application Java Servlet pages with JavaScript as the scripting language was chosen to be used. The reasons for this choice are discussed below.

· Java Servlet Pages – JSP is used for viewing of web pages at client end and JSP's website pages are translated into servlets at runtime. Highly compatible with all the platform .

· JavaScript – JavaScript, which is required for dynamic modification of elements, a basic and important requirement for the application

· Jquery – It is used to simplify the client side scripting and their syntax are designed to make it easier to navigate, animate, event handling and Ajax control.

4.5 ALGORITHM FOR MAKING LOOK ALIKE 3D BY USING WEB

The functioning of web based application is discussed in the algorithm below:

Step 1: Open the web browser and type http://localhost:8080/nextgenproject. This link open up the website Look Alike 3D in web browser. Here, localhost can be replaced by the IP address of the running server where the web application is uploaded. The figure 5.1 shown above is the front end for the client, which provide the access to the client for using the web based application. The website also provides basic access to client such as feedback, contact us and also tells the client about how does this technology works.

Figure 4.3: look Alike 3D Home Page

Step 2: Click on the technology tab given on the top and right to home. Here the technology behind look alike 3D is discussed. Technology defines to client how to operate the web based system and to follow the steps to generate the toolpath files. It will guide the client to how to operate the look alike 3D main tab.

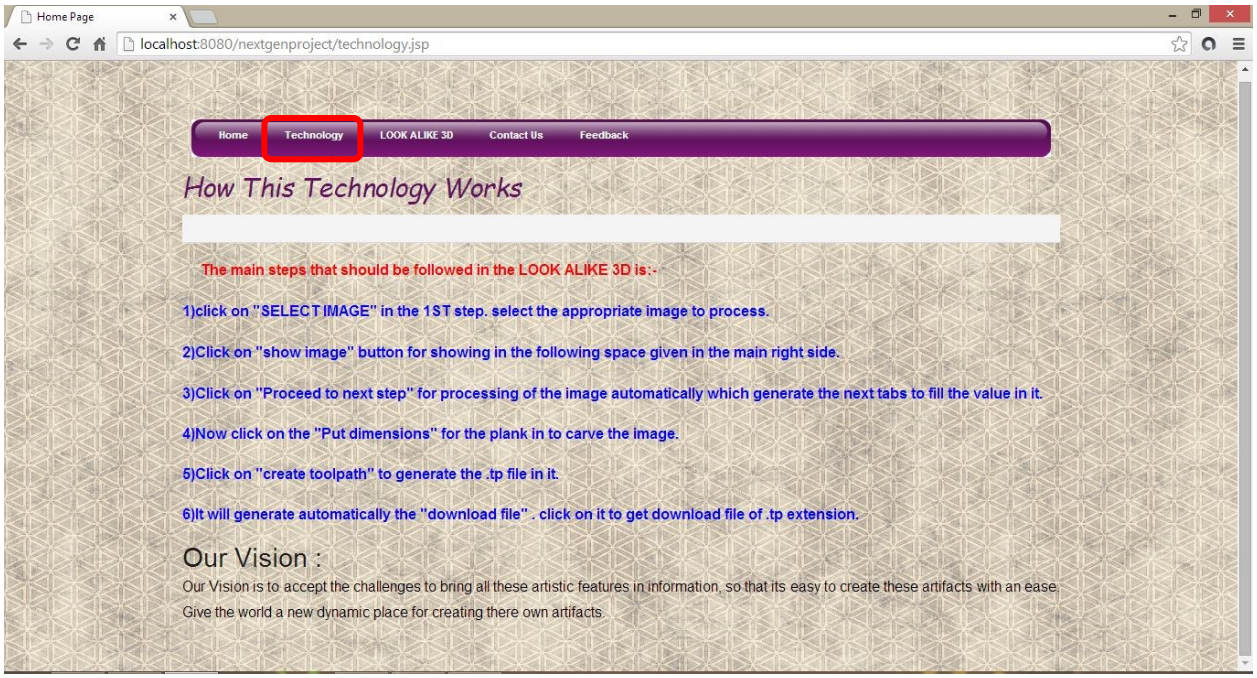


Figure 4.4: Technology Defines Procedure to be follow for Design.

Step 3: Click on the LOOK ALIKE 3D Link on the website. When the link look alike 3D has been clicked the website goes to the web user form, where the client or customer can enter the desired parameters. Here, the following parameters has been asked to the client to create design, such as

· Enter X dimensions for 3D look alike,

· Enter Y dimensions for 3D look alike.

· Radius of roughing tool.

· Radius of finishing tool.

Here the program will automatically compare the parameters of the image and then it will automatically give only one option to put in for plank size. And there are files generated for the roughing toolpath and another for the finishing tool path. So user has to define these two para meters also to make a stable toolpath file.

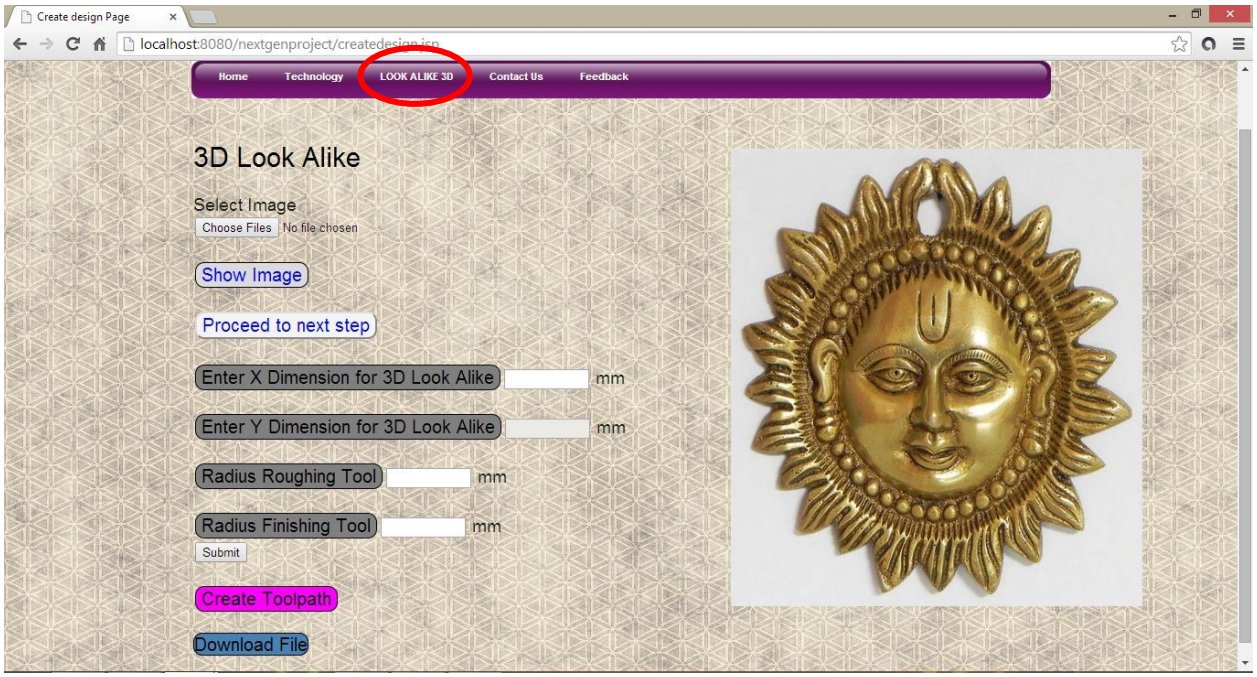


Figure 4.5: Parameters to create design.

Step 3: Click on the Submit button after defining the parameters. As soon as, the user or client defined the parameters in their respective textbox. The next step as shown in the figure 5.3 below is to click on the submit button to pass the defined value to the database. From the database, the text file get invoked and run the tool path file to create the desired shape and size of the canvas.

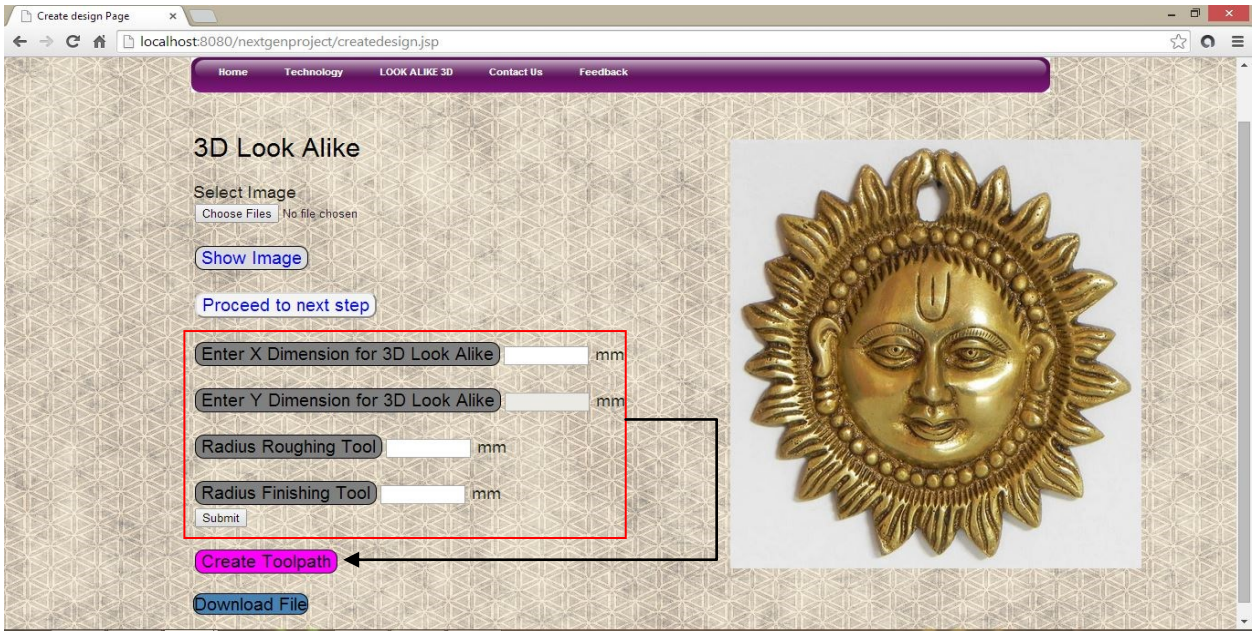


Figure 4.6: Put Parameters by submit.

Step 4: Click on the Create tool path after the completion of the previous step the tool path file has been created in the background database. As soon as, the tool path file has been created at the server end a notification is displayed on the client end informing that the “show the tool path, now you can click on the Show tool path file” link which is given on the bottom right side as shown in the figure 5.4 below.

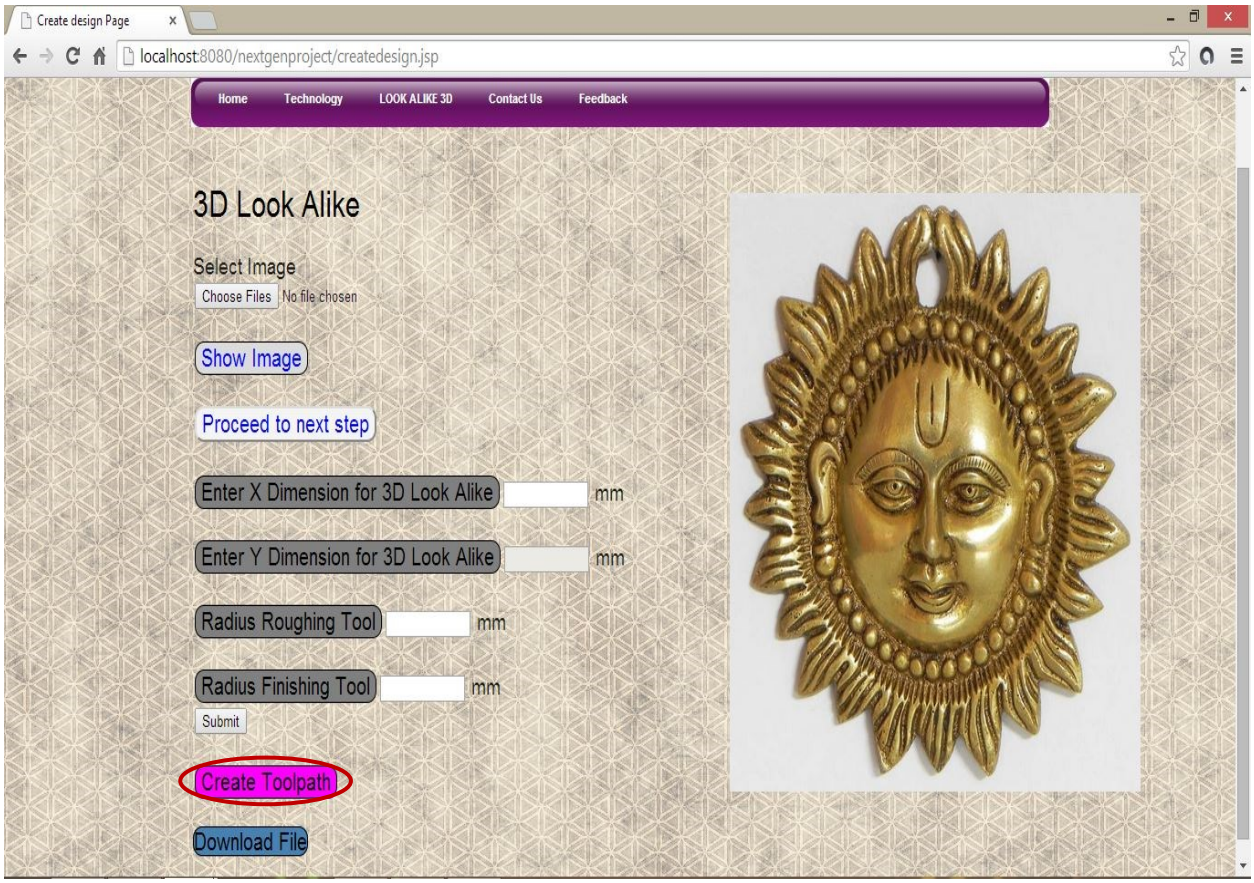


Figure 4.7: Create Toopath for Selected Image

Step 5: New window to see link to download toolpath of point cloud data and STL. As soon as the client/user click on the show or download link for tool path which automatically blink, then the client is directed to another webpage where he/she can see the pictures of the created Look alike 3D in different orientations. Also, the client is given with a download link from where he/she can download the pictures, part modeled and text file in the zip folder of the model as shown in the figure 5.5 below.

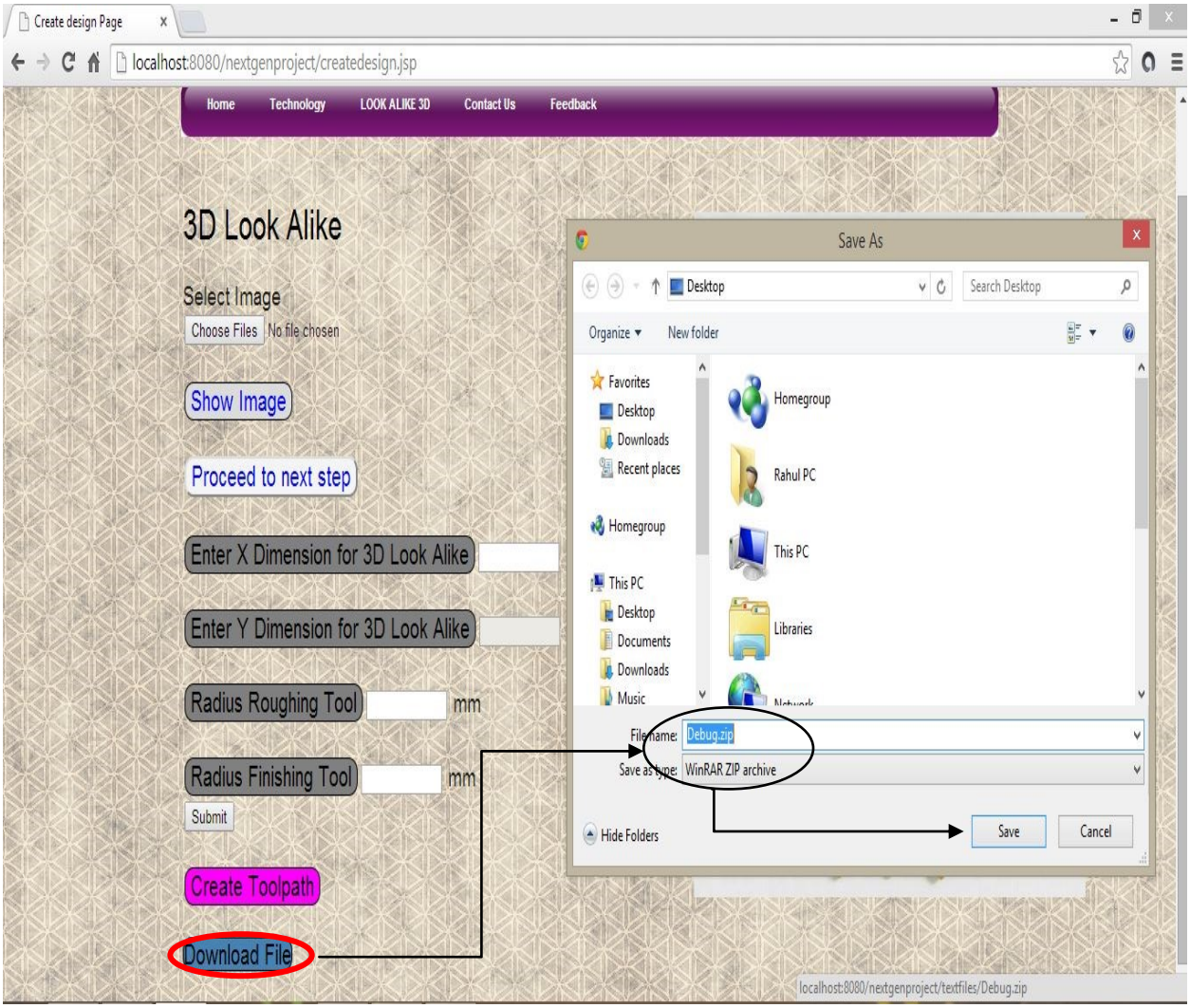


Figure 4.8: Download File Link

Step 6: Next step to create toolpath for the final Look alike 3D model. In this step, the user can further create toolpath for the final look alike 3D model which has been created by using web page through based application. As per the convenience, the user can generate raster toolpath and contour toolpath by clicking the button on the web page as shown in the figure 4.8.

4.6 FLOW CHART FOR WEB BASED APPLICATION AND TOOLPATH

The procedure discussed above for creating a web based look alike 3D and NC toolpath data can be shown in the form of a flow chart as given in figure 4.20. In the figure 5.10 the working procedure of the web implementation has been detailed, while figure 5.11 shows the detail working and controlling of the web based raster or contour NC toolpath generation.

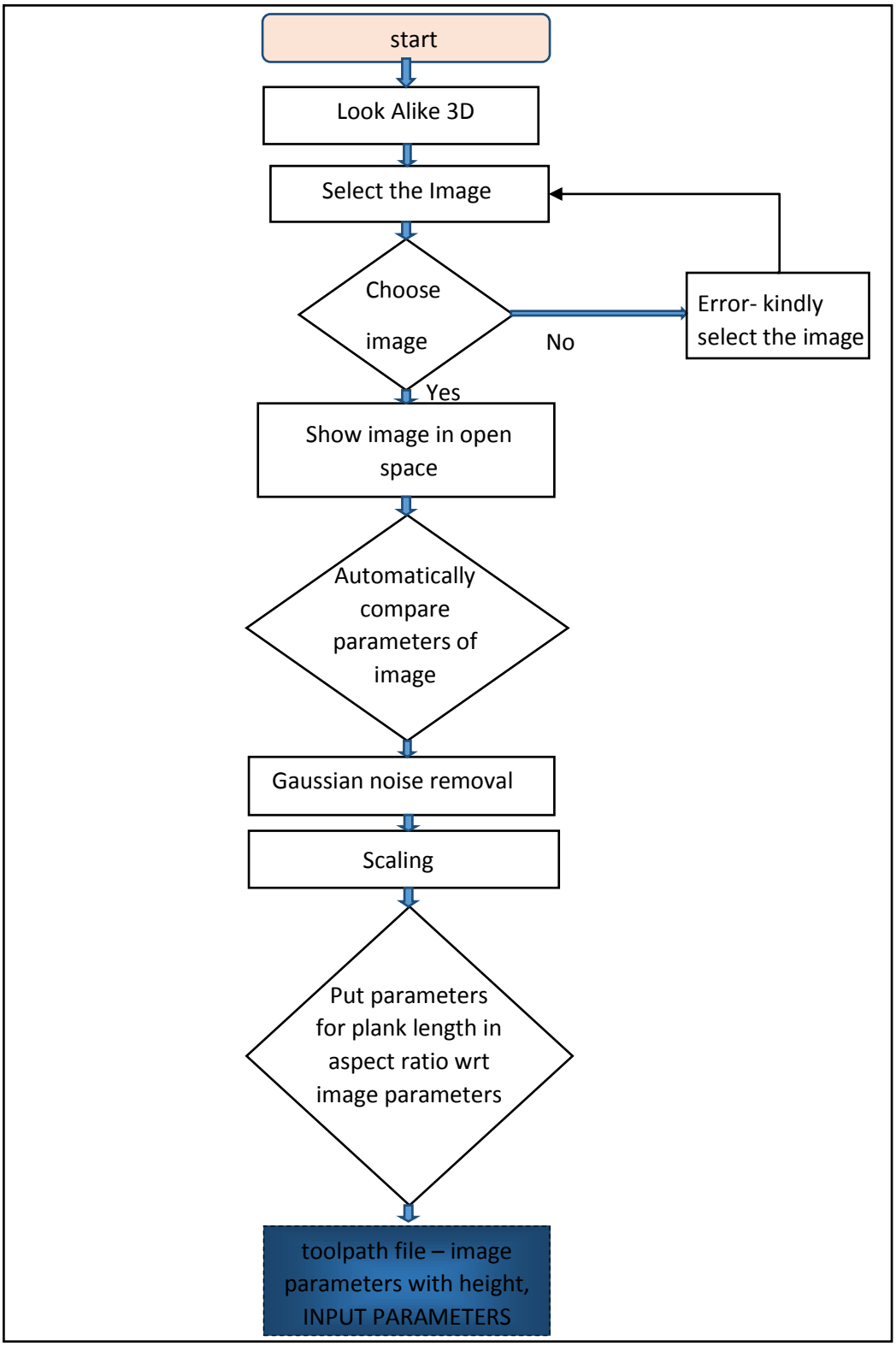


Figure 4.9: Flow Chart showing the Implementation of Web Based Application.

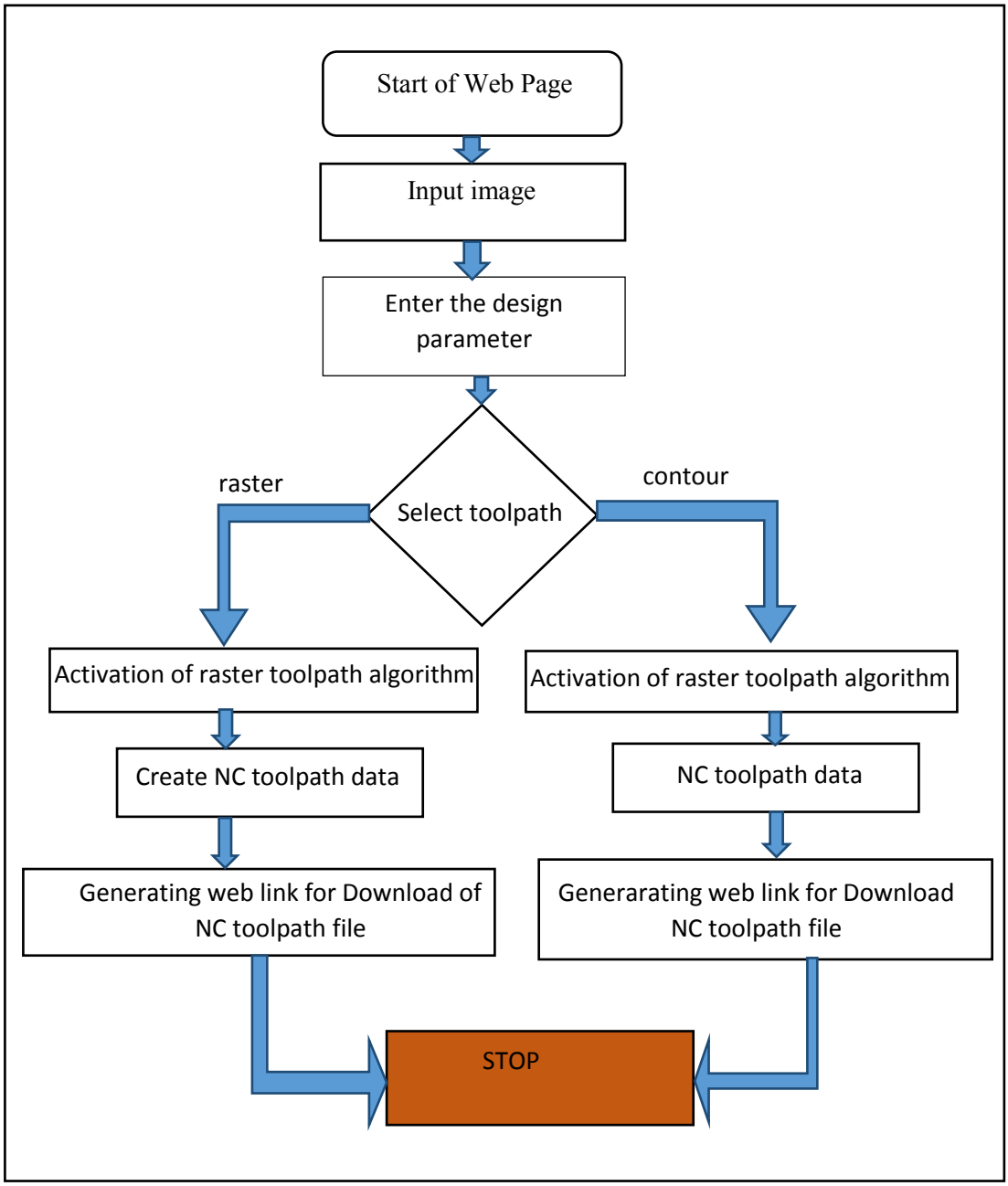


Figure 4.10: Flow Chart for NC Toolpath Generation in Web-Based Environment.

CHAPTER 5
RESULTS AND DISCUSSION

5.1 WEB ENABLED LOOK ALIKE 3D

The result and validation of the work shown in this chapter is actual working of the web based application with the help of screen shots. In the web based application, here it have the user defined parameters are entered by the user at the running time of the application, which is stored in the two different text files which are linked to each other in the tool path generation page. As soon as, the parameters are updated in the web based system, on entering the value in the web based system it will automatically generate the text file. These parameters are passed into function of the tool path code in which we have two text files one is for the only coordinates of the image data that is X, Y and Z (h_{max} mapped color intensity), and the next file will contain the X_{max}, Y_{max} and the enter parameter which for the user defined its max length for plank to be shown. In this chapter, the working of the whole web based application is presented with the help of following various illustration as discussed below.

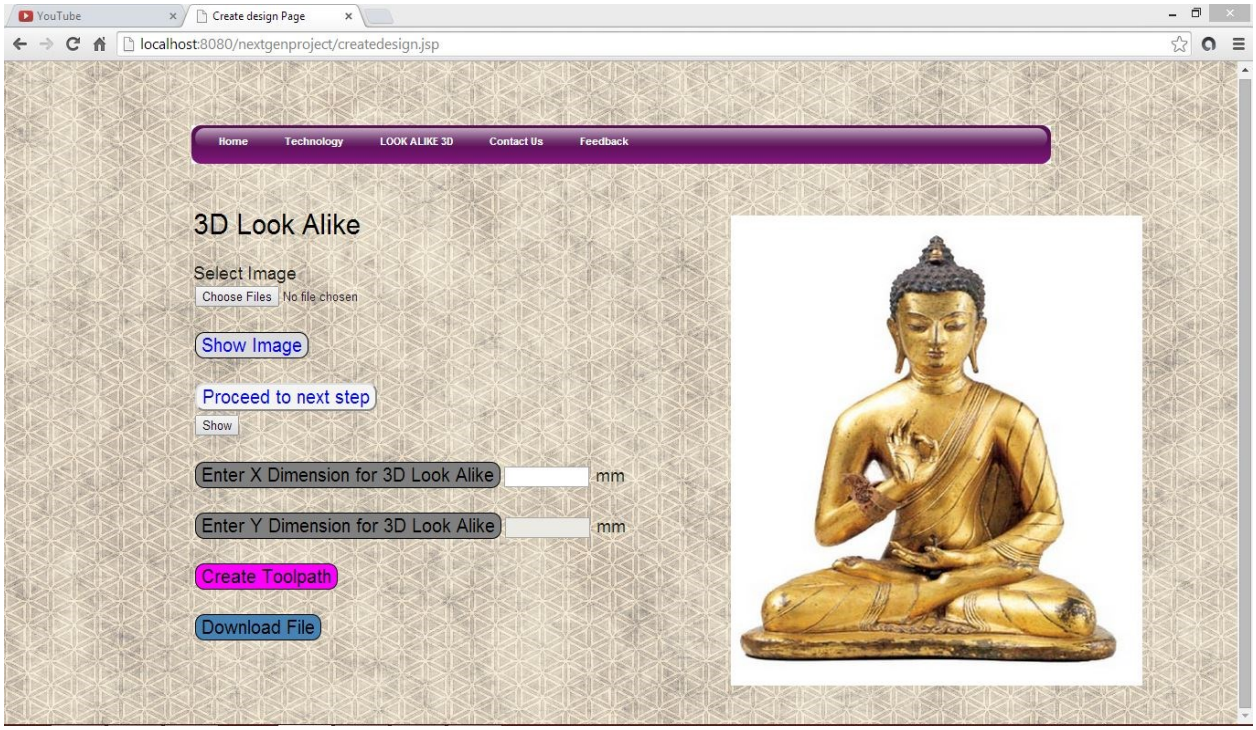


Figure 5.1: Web page for user defined input parameters to get tool path.

The figure 6.1 represents the web based form, which act as an input form for the image face to perform all the operations and then get the tool path for the feature. Here, by usinga single web

based form user can create his or any face image to emboss it in the best range of its height and then get the free toolpath files which can be treated on any CNC milling machine with ball end mill cutter. The illustration discussed below will give the required results as we defined our some input parameters in the web based model.

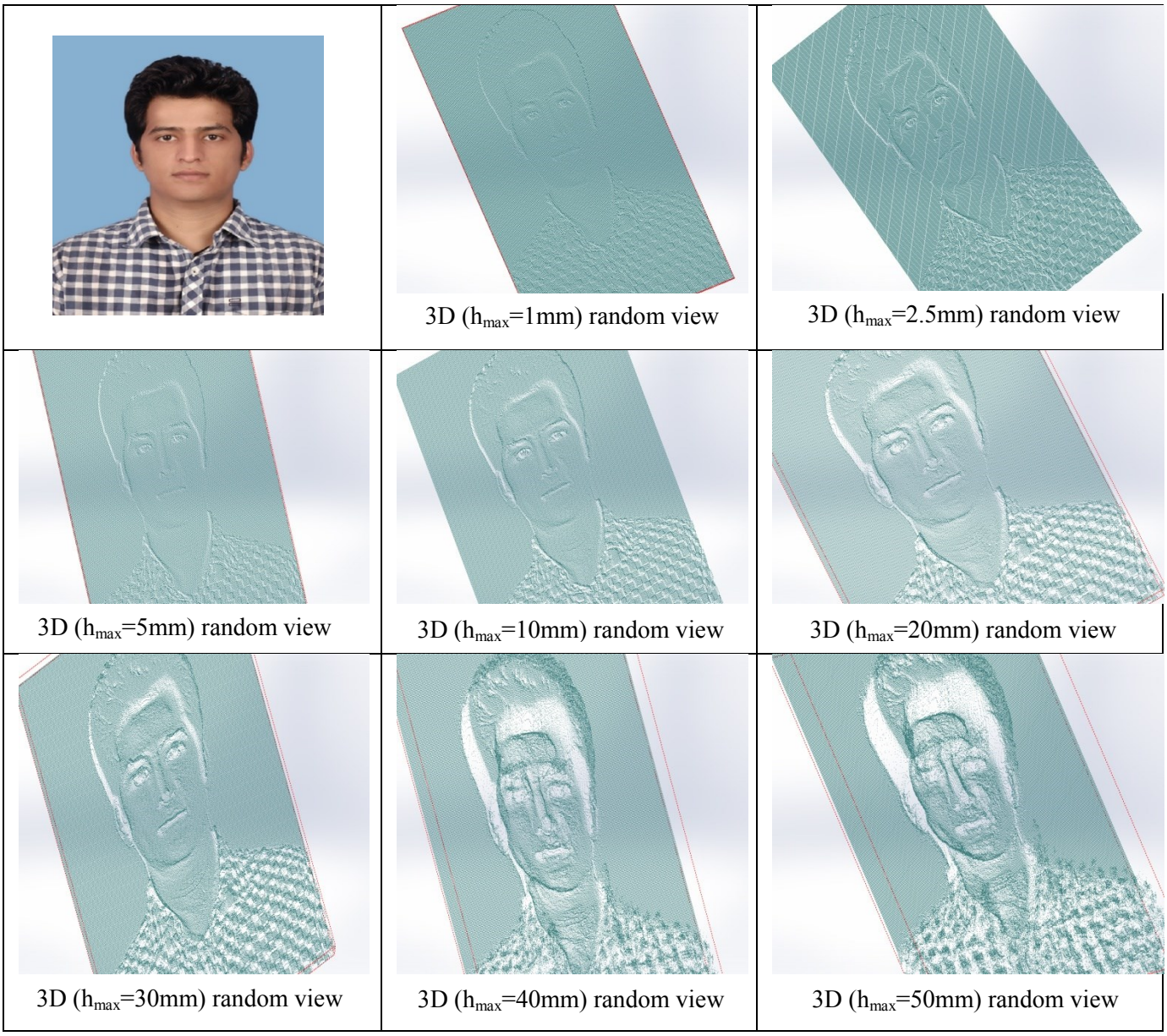


Figure 5.2: Different emboss result of face image1.

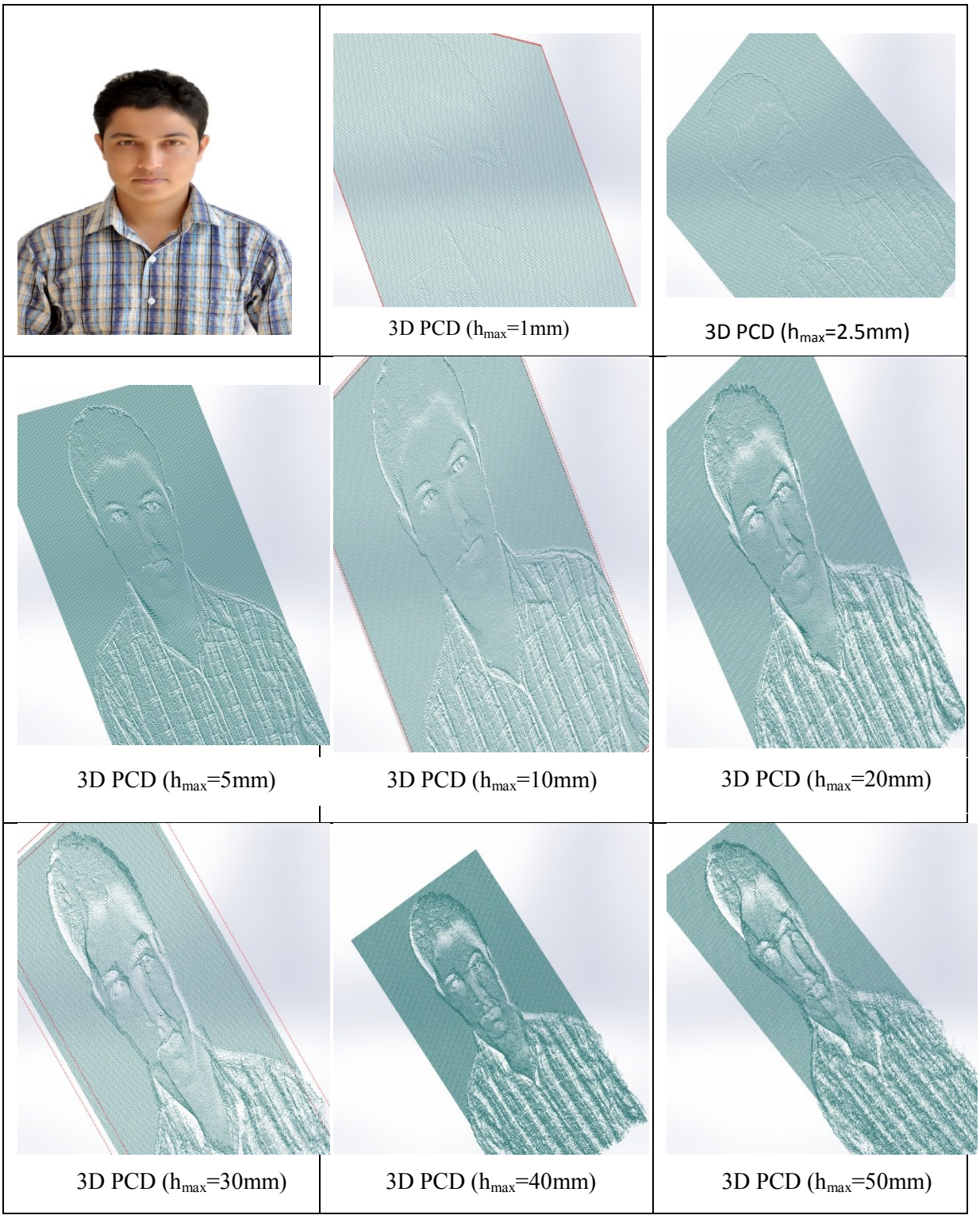
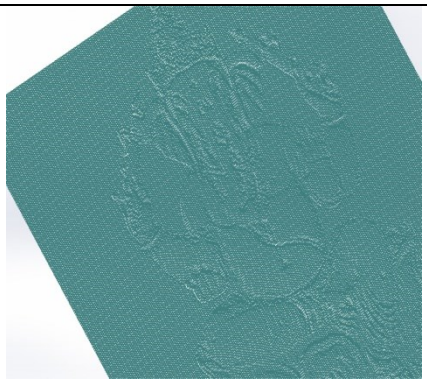


Figure 5.3: Different emboss result of face image2.

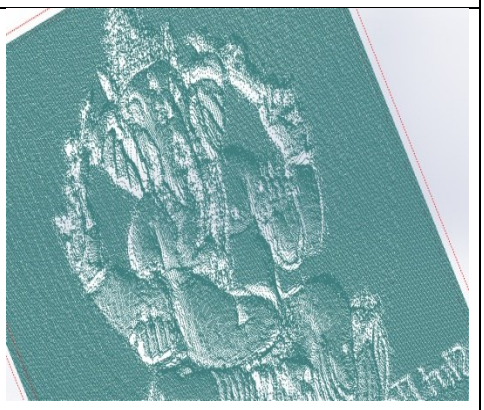


3D PCD (h_{max}=1mm)

3D PCD (h_{max}=2.5mm)

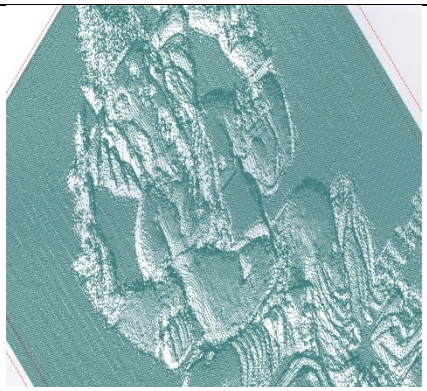
3D PCD (h_{max}=5mm)

3D PCD (h_{max}=10mm)

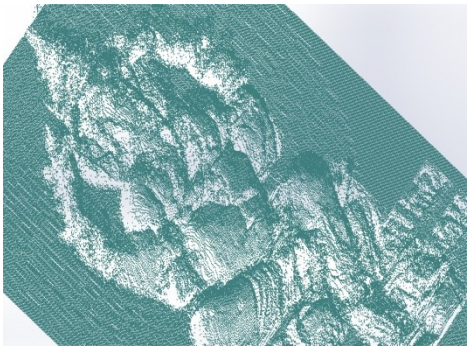


3D PCD (h_{max}=20mm)

3D PCD (h_{max}=30mm)



3D PCD (h_{max}=40mm)



3D PCD (h_{max}=50mm)

Figure 5.4: Different emboss result of image 3.

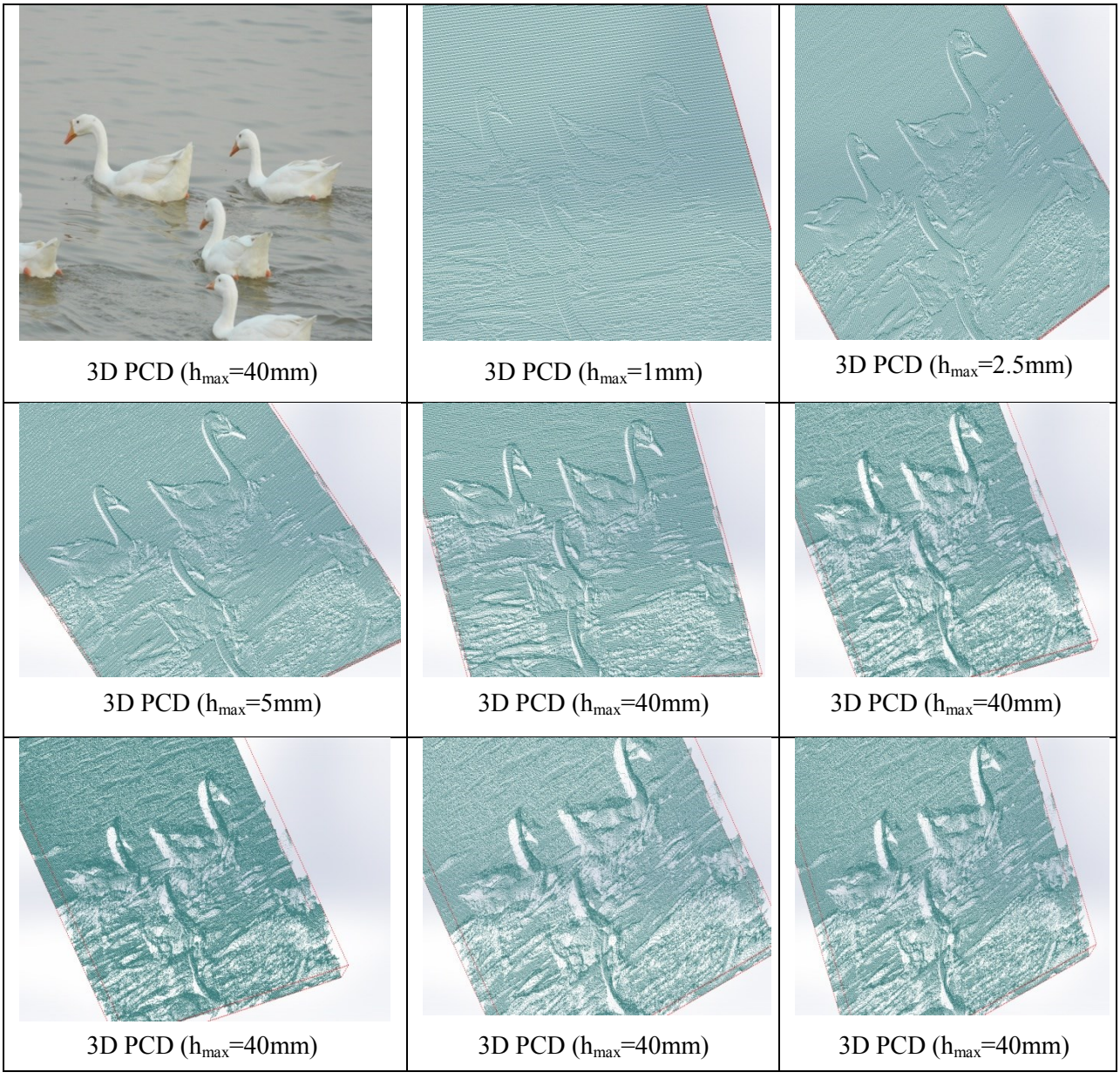


Figure 5.5: Different emboss result of image 4.

The above results proves that it is possible to model the 2 dimensional image to emboss or height mapped information can be provided so that a look like 3 dimensional model generated. All the results are shown in the figures of the different image is scan to 3D tool or add on provided in SolidWorks. The point cloud data is provided for the surface meshing and the results are collected on the visual inspection at the different height parameters and then a aspect ratio is taken under consideration for best output at different parameters. This concept will open the

doors for low cost trend for 2D to 3D embossed face images , manufacturing, easy and 24 hours accessibility for everyone, and user. Thus, this technology is a tool for the future web based 2D to 3D look alike.

On the evaluating the 3D part scan on the solid works, the appropriate range or depth which should be given to a particular M×N pixel range image depend on the visualization factor. For example 100×100 pixel image will give its best result under the range of 1 to 2.5mm and for 200×200 pixel image the best result under the range of 2.5 to 5mm and 300×300 pixel image gives best result in 5 to 6 and so on. The is a visualized observed result range for the image Hmax range. The range differ from the pixel size(M×N) of the image.

5.2 VALIDATION AND RESULT FOR NC TOOLPATH

The validation of the raster and contour toolpath has been validate by using toolsim software in State Initiated Design Centre (SIDC) for wood working lab in Thapar University. Patiala as illustrated for different type of images in figure(5.6).

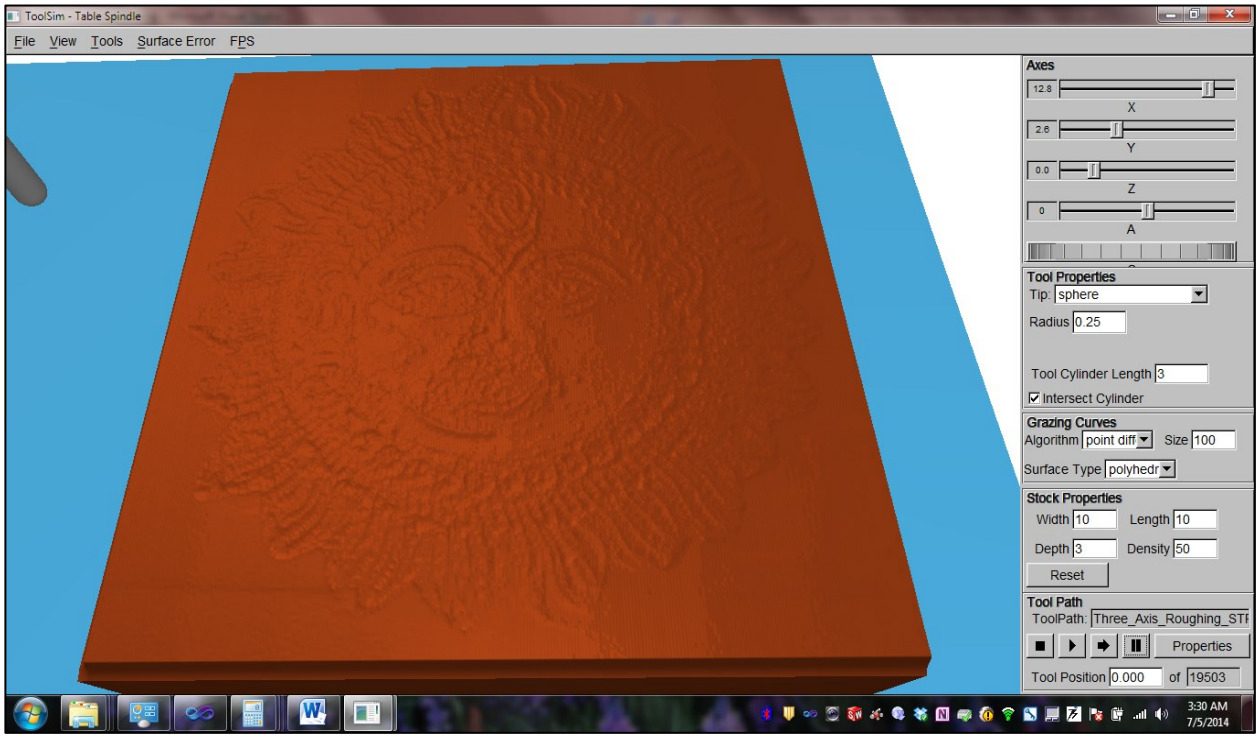


Figure 5.6 Roughing pass.

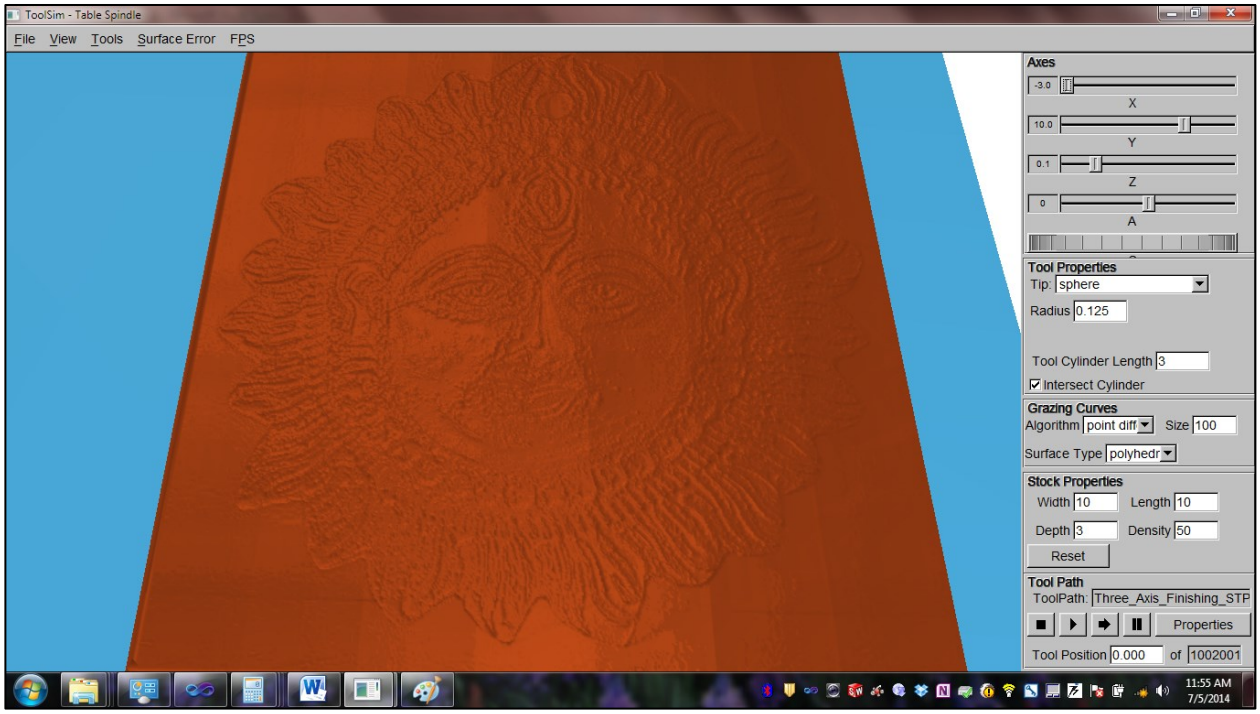


Figure 5.7: Finishing pass.

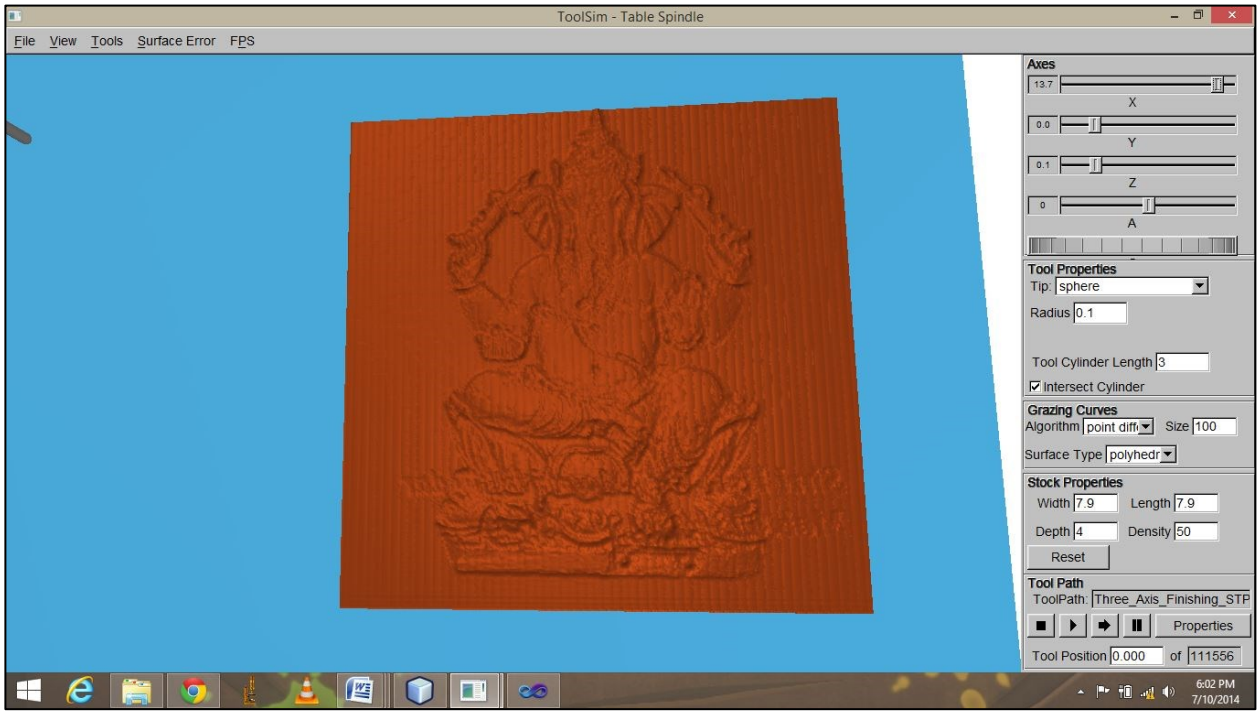


Figure: 5.8 finished final object.

Figure 5.8(a) simulator result for face.

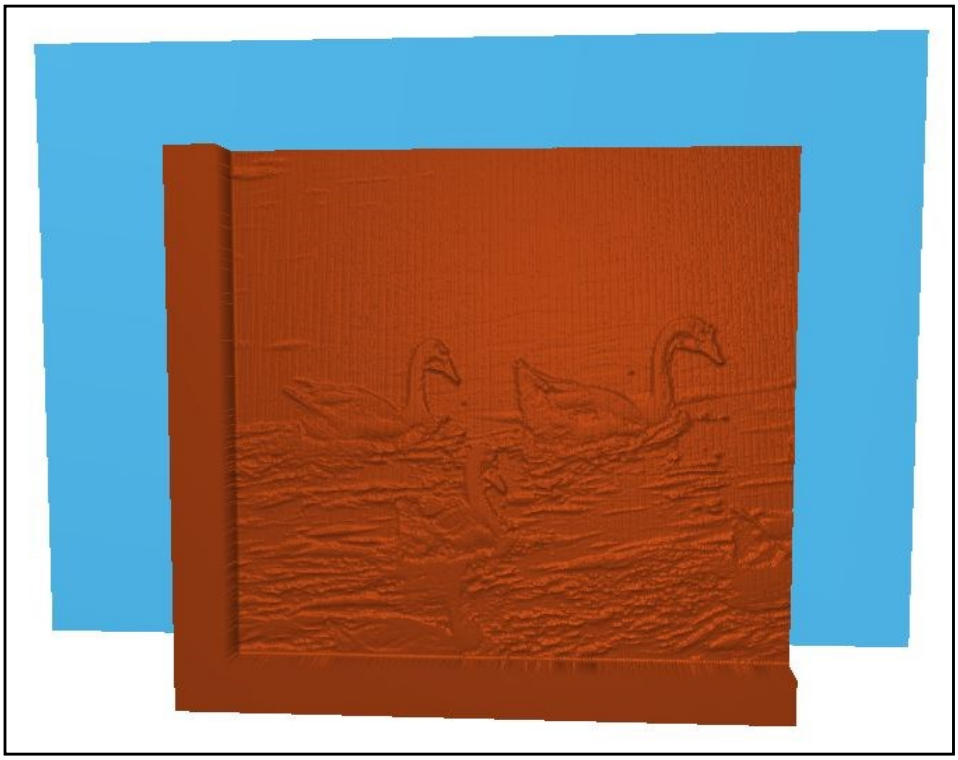


Figure 5.8(b) simulator result for scenery.

5.3 PHYSICAL REPRESENTATION OF WORK

The physical representation of the toolpath for finishing and roughing pass has been done in the mechanical workshop in CAM LAB with CNC vertical machining centre named as Chandra+.

Figure 5.9: CNC vertical machining centre.

5.4 TOOL SPECIFICATIONS

Tool used for machining the aluminum sheet carbide tool of 6mm in diameter. The clamp used for the tooling with same match fixed in the vertical machining centre.

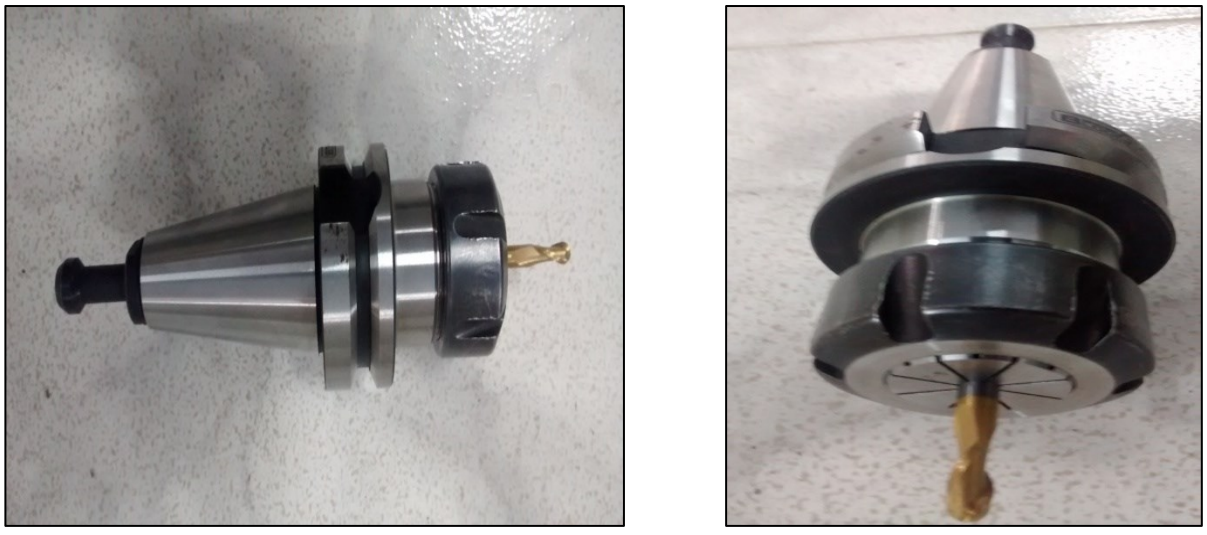


Figure 5.10.: Tool clamp with collate fixed with carbide tool.

5.5 CUTTING ALUMINIUM ON CNC MILLING MACHINE

The tool path algorithm has been put in the machine with the help of the flash drive used for the upload the data. This is the main task when worker has to be alert for machining and tool handling with some specific tool cutting coolant.

Figure 5.11: work piece final touch on machining centre.

5.6 FINAL OUTPUT OF THE TOOLPATH WITH MACHINING CENTRE

Final result with toolpath got through machine within about 24 hours of machining centre. The worker has to be alert on machining centre for electricity connectivity.

Figure 5.12: finished final output with machine centre.

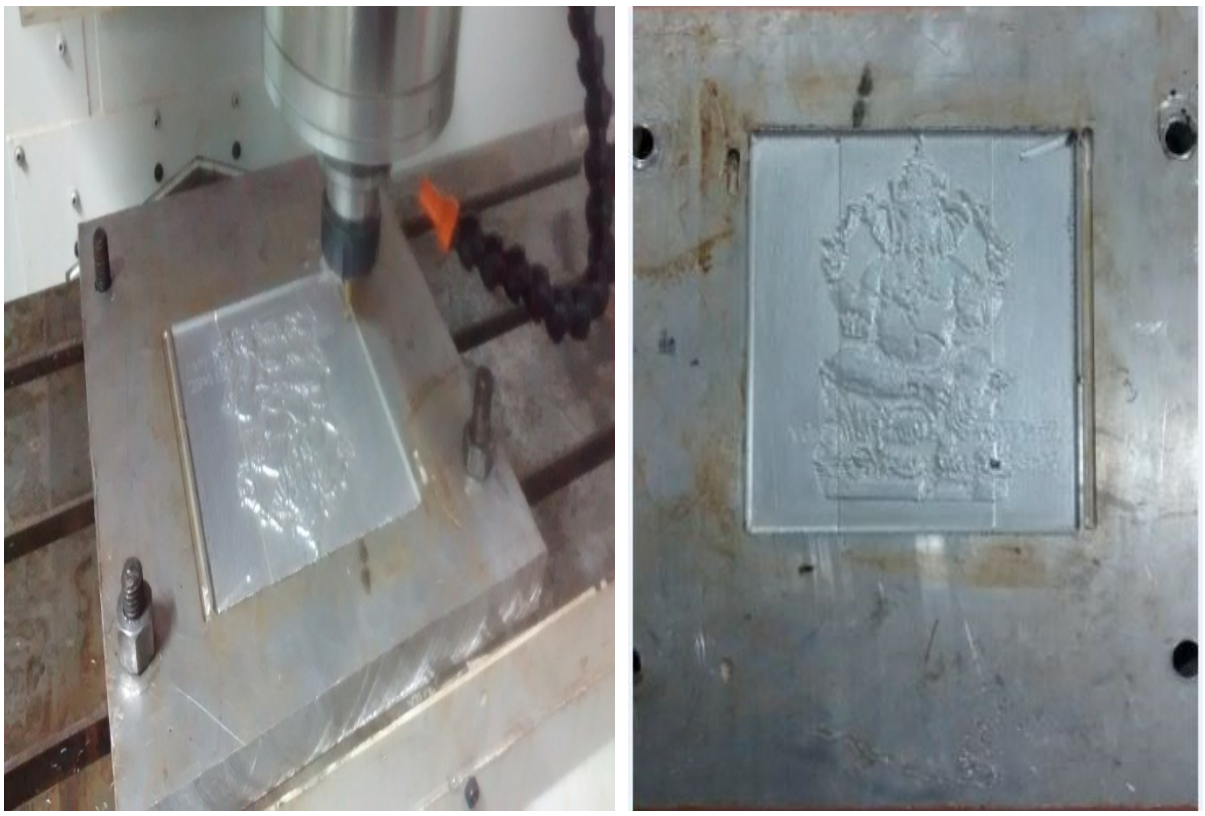


Figure 5.13: final result of LOOK ALIKE 3D

5.7. CONCLUSION

The main task of comparing the height map or the depth map compared for the different picture ratio discussed in this main chapter select a particular depth map for the different sizes of images. The main conclusions discussed here are:

1) The picture look alike 3D depth map will be depend on the size of the image. For example a image of 100 × 100 make a good depth map on 1 mm and for 200 image pixel values the best depth map in 1 to 2.5 and foe 500 × 500 image depth map will be 5 mm for best extrusion.
2) The image extrusion data depends on the color of hair and beard so that for this purpose of scaling the depth map in this algorithm not fit in this case.
3) Depend on the image complexity, the illumination or the intensity of the color in the images should be in the proper ratio. No sun light or shades through some object will destroy the point cloud data.

5.8 FUTURE SCOPE

The main work is in consideration of depth map for the particular size of the image and the toolpath generation with the web based enabled system. So there are very great exploration in the field of the image point cloud data manipulation and readjust ability of the data, toolpath generation with simulator online. The main future scope can be further discussed like:

1) The image point cloud data for the black or related in range of black region fall directly in lower range. So there a space to find the algorithm for readjustability of the color or the point cloud data.
2) Online toolpath simulator can be a large scope for finding the toolpath correctly for the workpiece.
3) The toolpath generation with maximum feed and speed and manage the vertical machining centre with minimum time span to complete the toolpath for aluminum workpiece and carbide tool for complex one.

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