REPORT ON

"3-D Documentation Of Cultural Heritage Sites"

For The partial fulfillment for the award of the degree of

Bachelor of Technology

Computer Science

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ABSTRACT

The Project is a open source tool for digital documentation of heritage which allows the user to perform various task inside the software by authenticating himself to the software with the allowance provided by the administrator. After authentication gives the user various functionalities (Point cloud processing, Image processing, getting the views of heritage site with the help of FreeCAD and Database querying) organized in a simple tool.

The domain of image processing provides unique functionalities, Some of its applicability is in Edge Detection, Corner Detection, RGB to HIS, HISto RGB, Texture Analysis and Change Detection and cracks Detections. The project uses python and C++ as a programming language and some functionality is accomplished using C++ mostly the database part. The libraries are of high importance in the project. After converting 3D point cloud to 2D image, the point and image attributes are stored in the PostgreSQL database and can be visualized by the user through interface. The user should be equipped with computing technology required for the working of this project, given the operational load to be handled. With only an input, the machine is left with an algorithm to give an output.

The project also includes Engineering drawing of heritage sites for viewing its different views like the Top view, Bottom view, Front View, Side view and many other by angle rotation. For this purpose FREECAD is used and it is must that the user should have the knowledge about this Architecture Framework which is totally open source.

ACKNOWLEDGEMENT

"No work can be completed successfully without the proper guidance and help of the trainer and other people"

This project report is also a manifestation of the invaluable guidance, suggestions, support and encouragement extended by various people.

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We wish that we will be able to make use of all the available resources and prepare a quality Project for IIRS.

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1. ABOUT THE ORGANISATION

Indian Institute of Remote Sensing (IIRS)

The Indian Institute of Remote Sensing (IIRS) - an ISO 9001:2008 institute, is a constituent unit of Indian Space Research Organization (ISRO), Department of Space, Govt. of India. Since its establishment in 1966, IIRS is a key player for training and capacity building in geospatial technology and its applications through training, education and research in Southeast Asia. The training, education and capacity building programmes of the Institute are designed to meet the requirements of Professionals at working levels, fresh graduates, researchers, academia, and decision makers. IIRS is also one of the most sought after Institute for conducting specially designed courses for the officers from Central and State Government Ministries and stakeholder departments for the effective utilization of Earth Observation (EO) data. To widen its outreach, IIRS has started live and interactive Distance Learning Programme (DLP) since 2007. IIRS has also launched e-learning course on Remote Sensing and Geo-information Science since August, 2014.

The Institute has a strong, multi-disciplinary and solution-oriented research agenda that focuses on developing improved methods/ techniques for processing, visualization and dissemination of EO data & Geo-information for various societal applications and better understanding of Earth's system processes. Currently, Microwave, hyper spectral and high-resolution EO data processing and their applications are some of the prime research areas. State-of-the-art laboratory and field-based instrumentation and observatories network help meeting the research goals and objectives.

IIRS hosts headquarters of Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP), affiliated to the United Nations and provides support in conducting the Remote Sensing and GIS training and education programs. IIRS also plays a key role in the activities of Indian Society of Remote Sensing (ISRS), which is one of the largest non-governmental Scientific Societies in the country.

2.OBJECTIVE

The objective of this software is to make an already existing application more efficient. The proposed system includes some added functionality to the existing system like-

- Bug Detection and Correction
- 3-D documentation of cultural heritage sites which further include
    - ✦ Image Processing(Damage Detection & cracks identification)
    - ✦ 2D to 3D and inverse transformation & change detection and
    - ✦ getting the drawings of different views of Heritage Sites

This project helps the user to detect minor as well as major cracks in the heritage sites which generally occurs with time. So, instead of manually visiting the site the user can get the point cloud data of the building from scanner and process it to find cracks and take further steps to recover it.

The project also helps the user to get different views of the site using Engineering Drawing tool which helps in getting views from all angles and then store them for further consideration.

3.SCOPE

This Project is basically a standalone application that runs on individuals personal computer, user needs to download every interface on the system that will be needed to run it. The user friendly environment benefits the user to easily detect cracks as well as changes that occured over time. Unlike manually detecting the cracks by visiting the sites the software helps to detect them through algorithms and sometimes it is impossible to detect very minor cracks which can be fulfilled under this software.

4. REQUIREMENT ANALISYS

4.1INTRODUCTION

The heritages all over the world are the properties a country can flaunt about. These heritages need to be maintained in order to sustain them over centuries. Precise documentation of cultural heritage status is essential for its protection and scientific studies carried out during the restoration and renovation process. The maintenance can though be done manually but in this and upcoming digital centuries, where we can doubt the remanence of manpower, we need to depend upon software which in turn raises the need for such a software that can maintain the heritages and their sustainability.

This project deals with development of software that can Analyze, Detect and Report about the Changes and Damages taking place or tending to occur over time, such that the heritages can be maintained well throughout.

The project requires the point cloud data from the Arial LiDAR (Light Detection and Ranging) Laser Scanners for any heritage site. This point cloud data gives a 3D image of the entire site. This data can be analyzed for changes over different time by comparing two or more LiDAR data.

The difference can be detected by comparing the two captured data over different time using algorithms for detecting the cracks and changes.

This will help us in a complete maintenance of the heritages as far as possible through 3D Digital Documentation.

This project provide us the functionality to view the cloud data by every angle and take its drawings and store them for the future references.

The data collected and analyzed can be stored in the database in multiple forms for future references.

The libraries are of high importance in the project. This project is intended to be used by any person with elementary knowledge of computing and who knows handling point

cloud. The only contribution of user should be of providing point cloud to be analyzed. The working of this project is based on point cloud and image processing concept. Moreover, after converting 3d point cloud to 2d image, the point and image attributes are stored in the PostgreSQL database and can be visualized by the user through interface. The user should be equipped with computing technology required for the working of this project, given the operational load to be handled. With only an input, the machine is left with an algorithm to give an output.

4.2 REQUIREMENT SPECIFICATION

In addition to the hardware and software requirement the user must possess knowledge of Image processing concepts ,Point cloud processing for which Cloud Compare software is useed , FreeCADa Engineering Drawing software to get views of heritage site as well as PostgreSQL is used at back-end for data storage. The user must be equipped with the knowledge of programming languages like C++ and Python.

4.3 HARDWARE AND SOFTWARE REQUIREMENT

The tool requires the following hardware, software requirements at the developer as well as the user‘s end and the following user characteristics:

4.3.1 HARDWARE REQUIREMENT:

- **RAM:** At least 4 GB
- **HDD:** 5 GB or more (Free space excluding data size)
- **Processor:** Intel(R) Core(TM) i3(or equivalent) @ 2.70GHz

4.3.2 SOFWARE REQUIREMENT

SOFTWARE	TYPE/PLATFORM	VERSION
OS	Windows OS	Windows 7 and above
Qt Creator	Microsoft Visual Studio 2013	QtCreator 4.0.1 Based on Qt 5.6.1(MSVC 2013,32 bit)
OpenCV	Microsoft Visual Studio 2014	OpenCV 3.2.0-vc14
Cmake	Qt 3.6.0	Cmake 3.7.2
Python	-	Python 2.7
PostgreSQL	-	PostgreSQL 9.3
PostGIS	PostgreSQL 9.3	PostGIS2.2
GDAL	-	GDAL 1.1

CloudCompare	-	-
FreeCAD	-	-

Table 1: Softwares with their required platform and version

QT Creator:
Qt Creator is an integrated development environment (IDE) that provides you with tools to design and develop applications with the Qt application framework. Qt is designed for developing applications and user interfaces once and deploying them to several desktop, embedded, and mobile operating systems. Qt Creator provides you with tools for accomplishing your tasks throughout the whole application .development life-cycle, from creating a project to deploying the application to the target platforms.

OpenCV:
OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. Being a BSD-licensed product, OpenCV makes it easy for businesses to utilize and modify the code. It has C++, C, and Python, Java and MATLAB interfaces and supports Windows, Linux, Android and Mac OS. OpenCV leans mostly towards real-time vision applications and takes advantage of MMX and SSE instructions when available.

Cmake:
Cmake is an extensible, open-source system that manages the build process in an operating system and in a compiler-independent manner. Unlike many cross-platform systems, Cmake is designed to be used in conjunction with the native build environment. Simple configuration files placed in each source directory (called CMakeLists.txt files) are used to generate standard build files (e.g., make files on UNIX and projects/workspaces in Windows MSVC) which are used in the usual way. Cmake can generate a native build environment that will compile source code, create libraries, generate wrappers and build executables in arbitrary combinations. Cmake supports in-place and out-of-place builds, and can therefore support multiple builds from a single source tree. Cmake also supports static and dynamic library builds.

PostgreSQL :
PostgreSQL is a powerful, open source object-relational database system. It has more than 15 years of active development and a proven architecture that has earned it a strong reputation for reliability, data integrity, and correctness. It includes most SQL: 2008 data types, including INTEGER, NUMERIC, BOOLEAN, CHAR, VARCHAR, DATE, INTERVAL, and TIMESTAMP. PostgreSQL runs stored procedures in more than a dozen programming languages, including Java, Perl, Python, Ruby, Tcl, C/C++, and its own PL/pgSQL, which is similar to Oracle's PL/SQL. We have used Python with it. PostgreSQL is suitable for storing spatial data.

PostGIS:

PostGIS is a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQl. PostGIS turns the PostgreSQL Database Management System into a spatial database by adding support for the three features: spatial types, indexes, and functions. Because it is built on PostgreSQL, PostGIS automatically inherits important "enterprise" features as well as open standards for implementation

PyQT4:

PyQt4 is a comprehensive set of Python bindings for Digia's Qt cross platform GUI toolkit. PyQt4 supports Python v2 and v3.

PyQt is one of the most popular Python bindings for the Qt cross-platform C++ framework. PyQt developed by Riverbank Computing Limited. Qt itself is developed as part of the Qt Project. PyQt provides bindings for Qt 4 and Qt 5. PyQt is distributed under a choice of licences: GPL version 3 or a commercial license.

Python2.7:

Python is a widely used high-level programming language for general programming an interpreted language, Python has a design philosophy that emphasizes code readability (notably using whitespace indentation to delimit code blocks rather than curly brackets or keywords), and a syntax that allows programmers to express concepts in fewer lines of code than might be used in languages such as C++ or Java.

Cloud Compare:

CloudCompare is a 3D point cloud processing software (such as those obtained with a laser scanner).It is now an independent open source project free software.

CloudCompareprovides a set of basic tools for manually editing and rendering 3D points clouds and triangular meshes.

FreeCAD:

FreeCAD is an open-source parametric 3D modeler made primarily to design real-life objects of any size.

Parametric modeling allows you to easily modify your design by going back into your model history and changing its parameters. FreeCAD allows you to sketch geometry constrained 2D shapes and use them as a base to build other objects. It contains many components to adjust dimensions or extract design details from 3D models to create high quality production ready drawings.

4.4 FEASIBILITY ANALYSIS

Technical Feasibility:
This project is technically feasible as all technologies used in this project are all easily available; all the python and C++ libraries used in this project are open source libraries easily available over the internet. So the project is technically feasible.

Schedule Feasibility:
This project is feasible as this project was completed in available time, the schedule that was decided before the start of the project has been strictly followed and hence the project was completed in the given time.

Economic Feasibility:
This project was economically feasible because we have used only freely available open source libraries which were available at free of cost, hence economically not much amount has been spent for this project.

Technical requirements:
The hardware and software requirements are very less. It occupies very less space. Python, QtCreator and its libraries being open sourced was easily be accessed. The language is easy to understand and its libraries make it more powerful. The user can also be a non- programmer and can easily access the tool due to the Graphical user interface which was made available to him.

4.5 PRODUCT FUNCTIONS:-

A. LOGIN(Admin):

Description:

- Admin wants to store and manage information
- Admin enters the username, passwordand database name in the login portal
- The enteries are first validated by checks. Ex:- Cannot connect to database. Invalid credentials
- All the enteries are verified
- If verification is successful, admin can add new user, manage user, create projects and manage projects

B. LOGIN(User):

Description:

- User wants to access the application
- Admin is responsible to add the new user to the database
- User enters the username, password and database name in the login portal
- The enteries are first validated by checks. Ex:- Cannot connect to database. Invalid credentials
- All the enteries are verified

- If verification is successful, User can create projects and manage project

C. FORGET PASSWORD:

Description:

- User wants to restore password
- The user needs to contact admin for restoring his/her password

D. ADD NEW USER:

Descripton:

- Admin wants to add new user to the system
- Admin will provide username and password for the user
- Admin can encrypt password for the user,can provide validity and manage permissions
- User created successfully

E. MANAGE EXISTING USER:

Description:

- Admin wants to manage existing user
- Admin can change password of the user by choosing the username
- Admin can update the details of user like validity, group and permissions
- Admin can delete user

F. **PROJECT AND UTILITIES**:

Description:

- Admin and user can make new project or select from the existing project and proceed further.

G. POINT CLOUD PROCESSING:

Description:

- Actors wants to process the 3D cloud data
- Point cloud processing involve five steps:
  - Visualize point cloud
  - Translation and Rotation
  - Registration
  - Unroll
  - Rasterize point cloud to give 2D image
- **VISUALIZATION OF POINT CLOUD**:

  Point Cloud can be visualized when user clicks on open button.

- **TRANSLATION/ROTATION:**

  Translation is a rigid transformation of the plane that moves every point of the point cloud to a constant distance in a specific direction. Translation and Rotation of point cloud data requires a point cloud to be selected for translation.

Translation is applied to align the point cloud with the reference point cloud for the purpose of registration and geo-referencing.

Rotation is a transformation which turns a point cloud about a fixed point, C, called the center of rotation. When working in the coordinate plane, the center of rotation should be stated, and it is not assumed to be at the origin. The point cloud can be rotated with the angle of rotation α, β, γ along x, y and z axis. During rotation, every point is moved the exact same degree arc along the circle defined by the center of the rotation and the angle of rotation.

- **REGISTRATION:**

Image registration is the process of aligning two or more images of the same scene. This process involves designating one image as the reference image, also called the fixed image, and applying geometric transformations or local displacements to the other images so that they align with the reference.

Here we are using point cloud data (LiDAR data). The 3D point cloud of the object surface can be obtained by optical equipment such as laser scanners, which can provide the basis for the establishment of the 3D model of the object.

The purpose of point cloud registration is to find a 3D rigid body transformation; so that the 3D coordinates of the point cloud at different angles can be correctly matched and overlapped.

There will be two ways:

1.*POINT PAIR REGISTRATION* - Pairing between points is known, closed form (analytic) solutions (Horn Point Cloud Registration Method).

2. *FINE REGISTRATION* - Pairing between points is unknown, iterative solutions (require initialization and only guarantee convergence to local optimum). Iterative solution that used here is ICP (Iterative Closest Point) algorithm.

- **UNROLL:**

This method unroll's a point cloud from a cylinder (or conical) shape onto a plane.

- *Cylinder*: Select a single point cloud.
  To unroll a cylindrical shape, the parameters
  - are: axis of revolution (X, Y or Z) cylinder
  - radius
  - and optionally a point on the axis
- *Cone:* Select a single point cloud.
  To unroll a conical shape, the parameters are:
  - axis of revolution (X, Y or Z)
  - half angle indegrees the cone
  - apex position in 3D
- *Straightened Cone:* Select a single point cloud.

To unroll a straightened conical shape, the parameters
 are: axis of revolution (X, Y or Z) the cone apex
 position
 the base radius of the 'straightened' cone (= cylinder)

- **RASTERIZATION:**

The main purpose of this tool is to rasterize a point cloud (i.e. convert it to a 2.5D grid) and then export it as a new image to perform further image processing. Rasterization is the task of taking an unrolled point cloud and converting it into a raster image (pixel or dots), to store in any format. In normal usage, the term refers to the rasterization of 3D models onto a 2D plane for display on a computer screen (―screen space‖) is often carried out by fixed function hardware within the graphics pipeline.

We can say that rasterization is used to solve the visibility problem. Visibility consists of being able to tell which parts of 3D objects are visible to the camera. Some parts of these objects can be hidden because they are either outside the camera's visible area or hidden by others objects.

The terms rasterization comes from the fact that polygons (triangles in this case) are decomposed in a way, into pixels and as we know an image made of pixels is called a raster image.

Rasterization usually reduces the image to one flat layer, and thus limits edit ability to a minimum. You will want to keep a non-rasterized version of your file archived at all times, just to make adjustments later, if necessary

H. DATABASE QUERYING:

Description:

- Actors want to store and retrieve information.
- The database querying portion includes functionalities as follows: User Registration

  - User Login
  - Administration maintenance of Users
  - Storage of data in three formats,
    - Raster
    - Matrix
    - Image
  - Retrieval of data for its processing

I. CHANGE DETECTION:

Description:

- User wants to detect change between the two cloud image taken over different times.
- This feature is used to perform damage detection in which user has to input two images and using the feature of change detection we can detect the change

between two images taken at different time, doing so we can find the change that has occurred over that period of time.

- The predefined function of OpenCV library calculates the difference between two input test images by using subtract function which calculates the perelement difference between two arrays or array and a scalar.
- User has to load Pre and Post image from the database by providing the image ID and then the change is detected which is displayed in new window.

J. 3D CRACK DETECTION:

Description:

- User wants to view the detected crack in 3D
- User has to load Pre and Post image from the database by providing the image ID and then the change is detected which is displayed in new window.
- The user have to save the change in some location and then crop the changed portion to view it in 3D
- User has to click the the 3D_View button which further redirects to cloud compare window where he/she has to open the Dharohar.csv file to view as a 3D rasterised image.

K. ENGINEERING DRAWING:

Description:

- User wants to get the views of the cloud image.
- User has to create mesh data in .stl format of cloud data using CloudCompare which is in .txt format.
- Mesh data is opened in FreeCAD and its shape is created using part workbench.
- ***Part Wokbench****:* The solid modelling capabilities of FreeCAD are based on the Open Cascade Technology (OCCT) kernel, a professional-grade CAD system that features advanced 3D geometry creation and manipulation.

  The Part Workbench allows the user to access and use the OCCT objects and functions. Part objects, unlike Mesh objects, are more complex, and therefore permit more advanced operations like coherent boolean operations, modifications history, and parametric behaviour.

  OCCT Geometric Concept*:*In OpenCascade terminology, we distinguish between geometric primitives and topological shapes. A geometric primitive can be a point, a line, a circle, a plane, etc. or even some more complex types like a B-Spline curve or a surface. A shape can be a vertex, an edge, a wire, a face, a solid or a compound of other shapes. The geometric primitives are not made to be directly displayed on the 3D scene, but rather to be used as building geometry for shapes. For example, an edge can be constructed from a line or from a portion of a circle.

  The geometric types actually can be divided into two major groups: curves and surfaces. Out of the curves (line, circle, ...) you can directly build an edge, out of the surfaces (plane, cylinder, ...) a face can be built. For example, the geometric primitive line is unlimited, i.e. it is defined by a base vector and

a direction vector while its shape representation must be something limited by a start and end point. And a box -- a solid -- can be created by six limited planes.

From an edge or face you can also go back to its geometric primitive counterpart.Thus, out of shapes you can build very complex parts or, the other way round, extract all sub-shapes a more complex shape is made of.

- User has to select Drawing workbench to get the views of data through different angles.
- ***Drawing Workbench:***The Drawing module allows you to put your 3D work on paper. That is, to put views of your models in a 2D window and to insert that window in a drawing, for example a sheet with a border, a title and your logo and finally print that sheet.
- These drawings are then stored in a database and can be retrieved whenever needed through Cloud Compare.

4.6 USE-CASE DIAGRAMS

The following interfaces will be provided:

USER -

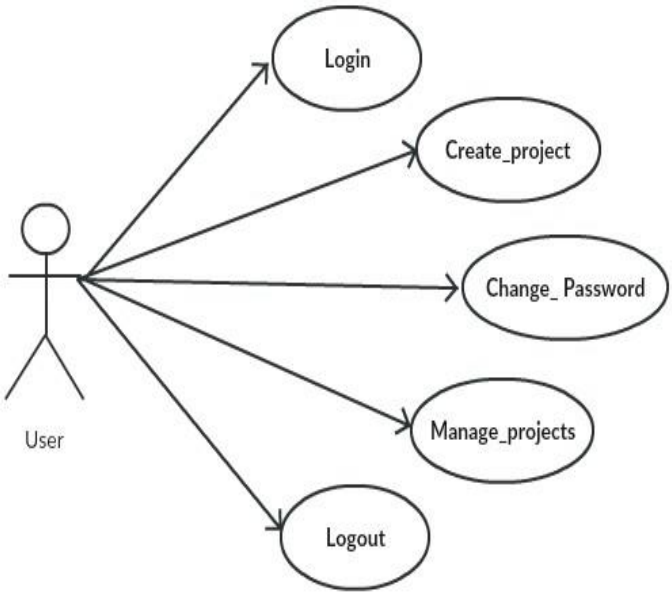

Fig 1. User Use Case.

LOGIN	**User**	Login the Software
	Trigger	User wants to Login for performing the tasks
	Precondition 1	User must be registered by the administrator.

	Post condition 1	User can then make new project or can work on the existing one.
CREATE_PROJECT	User	Create new project
	Trigger	User wants to create new Project for performing the tasks
	Precondition 1	**User must be logged in.**
	Post condition 1	User can detect changes and cracks in Heritage site, can get different views using FreeCAD and can do point cloud Processing using CloudCompare.
CHANGE_PASSWORD	User	**Change his/her password**
	Trigger	User wants to change his/her password for performing the tasks.
	Pre condition 1	User must remember the old password
	Post condition 1	User can than login with the help of another password.
MANAGE_PROJECTS AND UTILITIES	User	**User can manage existing projects**
	Trigger	User wants to manage the projects for performing the tasks.
	Pre condition 1	User must create a project to manage
	Post condition 1	User can grant or revoke the insert and select privileges to the specific user.
	User	**Logout of the system**
LOGOUT	Trigger	User wants to log out of the system
	Precondition	User must have logged in

	Postcondition	User logged out of the system successfully

Table 2. Description of User Use Case

ADMINISTRATOR–

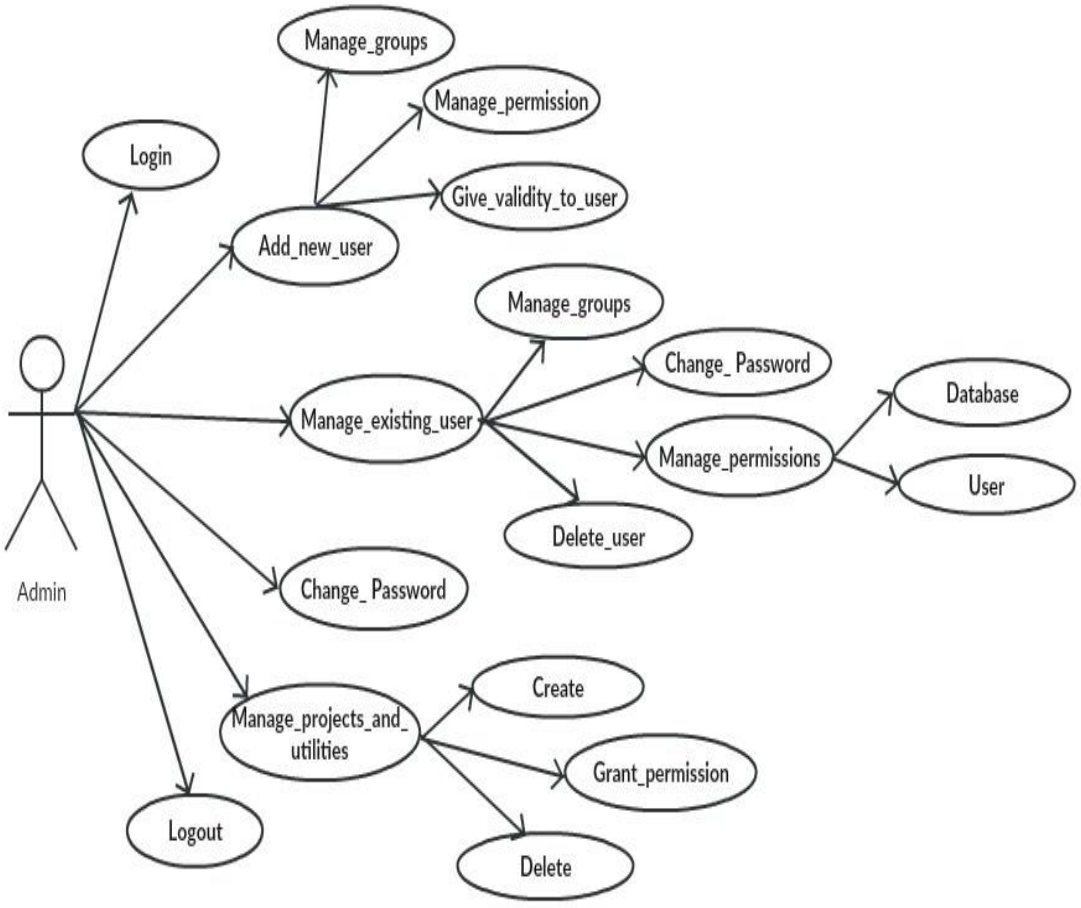

Fig 2. Administrator Use Case

	Admin	**Login to the system**
	Trigger	Admin wants to Login for performing the tasks

LOGIN	Precondition	Admin must have valid username and password
	Postcondition 1	add new users
	Postcondition 2	manage existing users.
	Postcondition 3	create new projects or can work on existing one.
	Postcondition 4	delete the users.
	Postcondition 5	Change password.
MANAGE_EXISTING USER	Admin	**Manage the existing user**
	Trigger	Admin wants to manage the existing user.
	Precondition	Admin must be logged in.
	Postcondition 1	change the password of users.
	Postcondition 2	manage groups and permissions
	Postcondition 4	delete the users.
ADD_NEW_USER	Admin	**Add new users.**
	Trigger	Admin wants to add new users to the system.
	Precondition	Admin must be logged in.
	Postcondition 1	manage groups and permissions
MANAGE_PROJECT AND UTILITIES	User	**Manage projects and utilities**
	Trigger	Admin wants to manage the projects for performing the tasks.
	Pre condition1	Admin must create project to manage
	Post condition 1	Admin can grant or revoke the privileges from specific user.
CHANGEPASSWORD	User	**Change his/her password**
	Trigger	Admin wants to change his/her password for performing the tasks.
	Pre condition	Admin must know the original password
	Post condition	Admin can then login with the help of another password.

LOGOUT	User	**Logout the Software**
	Trigger	Admin wants to Logout from the system.
	Precondition	Admin must be logged in.
	Post condition	Admin will be logged out.

Table 3. Description of Administrator Use Case

4.7 SOFTWARE SYSTEM ATTRIBUTES

There are a number of quality attributes of software that can serve as requirements. It is important that required attributes be specified so that their achievement can be objectively verified.

RELIABILITY:

All the information provided by the website is reliable.

AVAILABILITY:

If he or she is unregistered they should contact the administrator so that the admin can register them and the user is then allowed to browse through the application.

This project is available to all the users who have installed all the software that are needed for this application to work.

SECURITY

The authorization mechanism of the system will block the unwanted attempts to the software and also let the system decide which privileges the users possess. The system can be used by admin as well as other users, so there are different levels of authorization. The system has different modules which have been assigned certain functions, thus providing data abstraction and encapsulation.

MAINTAINABILITY

The requirements and modules that are explained in this document are enough to satisfy the user's needs and requirements. The maintainability shall be easily done by integrating new modules and updating the existing modules at specific intervals of times.

FLEXIBILITY

Website can be used by different actors in their own manner. For the developers and designing team, the operational program can be modified and debugged so as to provide enhancements in the website.

PORTABILITY

This software is created in a proven portable language (C++ and python) and thus can easily be accessed by all.

5. USER CHARACTERSTICS

Administrator:

Administrator is responsible for registering the new user, updating the user details, adding or removing the user records. Admin can create new project as well as manage existing projects.

End user:

End user is added by the administrator. The user can login, create new project, for determining the different views of the heritage site, process the Point Cloud for registration, translating and unrolling for further saving the Post and Pre Images in the database and then detect the changes and determine the cracks in the heritage site.

6 . ASSUMPTIONS AND DEPENDENCIES

- The user's computer can have any of the listed operating systems: Windows XP or later versions.
- This project depends on Python bindings like GDAL, matplotlib, numpy, pygame, PyQt4, scikit-image, scikit-learn, scipy, secure-smtplib, affine, imutils, pandas, psycopg2,cx_freezeand some other softwares also like opencv, CMake etc.
- One of the major dependency is the version of python as it works only on python 2.7
- The accuracy of the information is the responsibility of all users.
- If any user will forget her/his password than the administrator have the authorituy to give new password to the user**.** The user needs to contact the admin for the same

7. SYSTEM DESIGN

7.1 HIGH LEVEL DESIGN:

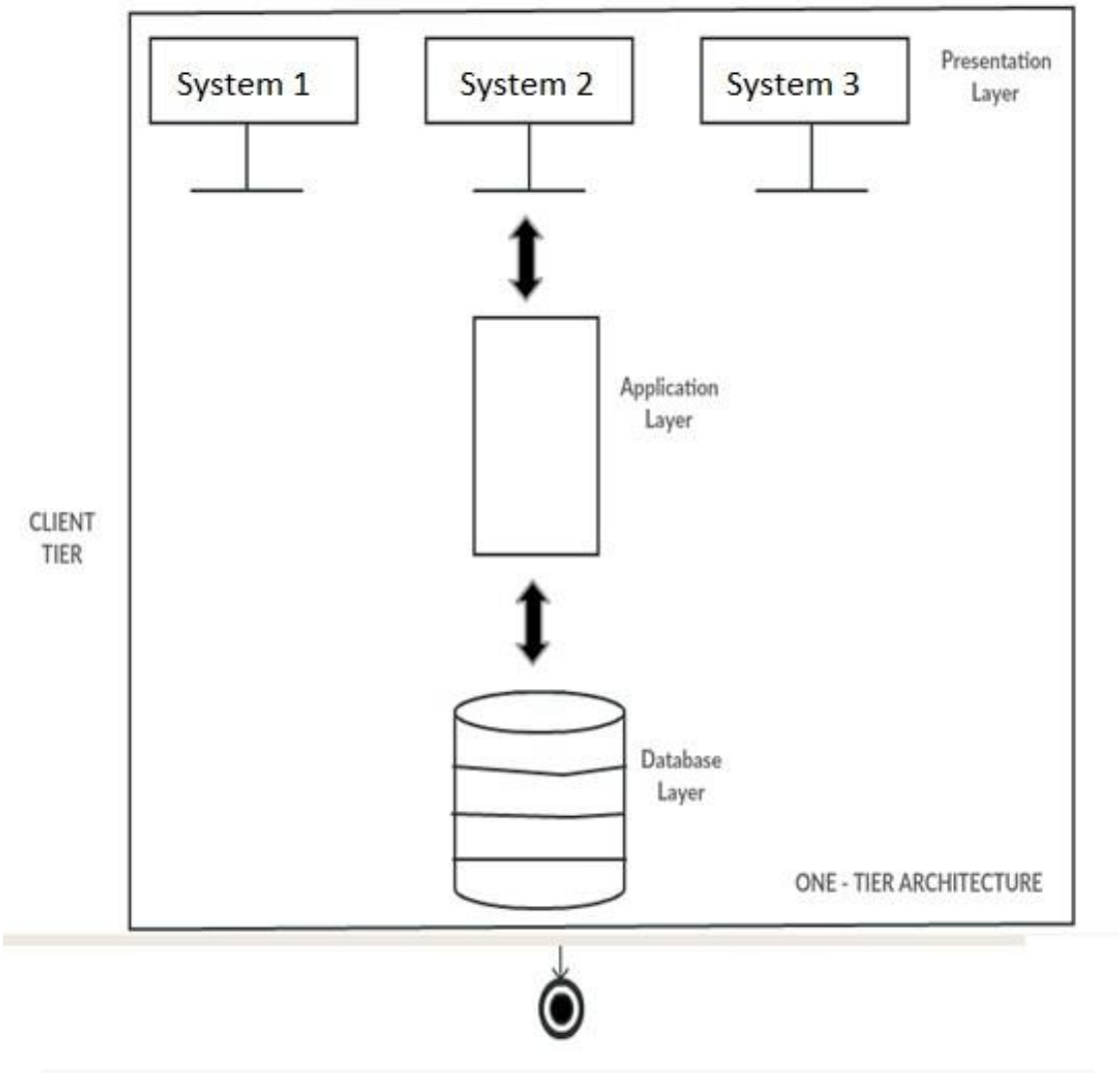

Fig.3 Client Tier: One Tier Architecture.

One Tier architecture has all the layers such as Presentation, Business, Data Access layers in a single software package. Applications which handles all the three tiers such as MP3 player, MS Office are come under one tier application. The data is stored in the local system or a shared drive.

Basically, a one-tier architecture keeps all of the elements of an application, including the interface, middleware and back-end data, in one place. Developers see these types of systems as the simplest and most direct. Some experts describe them as applications that could be installed and run on a single computer.

7.2 DATABASE DESCRIPTION:

PostgreSQL 9.3 has been used as the backbone for the backend of our project. PostgreSQL is the most powerful and suitable software for the combination of Python and PostGIS, which is a spatial database extender for PostgreSQL, object-relational database.

Authentication-

The authentication part comes at high necessity where the question of confidentiality arrives. This section is required for both normal users and Administrators. The registered users can authenticate themselves and login to the application only when he can proceed with his tasks.

The user authenticated if is a normal user, gets access to only manage his projects, while if he is an administrator, he gets an allowance to manage the users as well as all the projects.

Only the administrator has the authority to delete projects.

In case, a user forgets his password, he has to request the administrator for a new password and ones the administrator changes the password, the user gets notified about it. This is done to maintain a two way security to prevent unauthorized modifications.

Project Management-

All users and administrators get the authority to create new projects and manage existing ones. The Administrator can manage all the projects while the others can only manage projects created by him or permitted access by the administrators. Both users and administrators can grant another user the privilege to insert and select data to and from the database as well as revoke earlier privileges.

User Management-

The Administration is the only one who gets the authority to manage users. He can add new users and manage existing users as in, Provide the user validity, change his password,

- Add his to a group, encrypt his password,
- Allow his permissions to manage database and users, for both new and existing users. He can also delete an existing user or revoke his rights.

Database Creation-

For the database to get accessed, we first need to create the database, store data (image pixels) into it and access and visualize it accordingly. All the extracted properties and values of the point cloud will be stored in the database and will be retrieved from the same for the visualization of the data and values. Values which are stored in the database is:

X,Y,Z Co-ordinate -

The X, Y, Z co-ordinate of the points of the point cloud will be extracted and stored directly from the ASCII text file of point cloud..

7.3 DATABASE DESIGN:

A) project_image :

Field	Type	Description	Constraint
Rid	Serial	Represents the Id of rasterized image.	Primary Key
Filename	Text	Represents filename in tif format	Not null

Table 4. Structure of project_image **B)**

project_rdt :

Field	Type	Description	Constraint
Rid	Serial	Represents the Id of rasterized image.	Foreign Key
X	double precision	Represents value of Xcordinate	Not null
Y	double precision	Represents value of Y coordinate	Not null
Z	double precision	Represents value of Zcordinate	Not null

Table 5. Structure of project_rdt

C) part_drawings :

Field	Type	Description	Constraint
part_id	Serial	Represents the Id of drawing sheet.	Primary Key
file_extension	text	Represents the extension of file	Not null
drawing_data	bytea	Represents the drawing sheet	Not null

Table 6. Structure of part_drawings

7.4 ACTIVITY DIADRAM:

ADMIN:

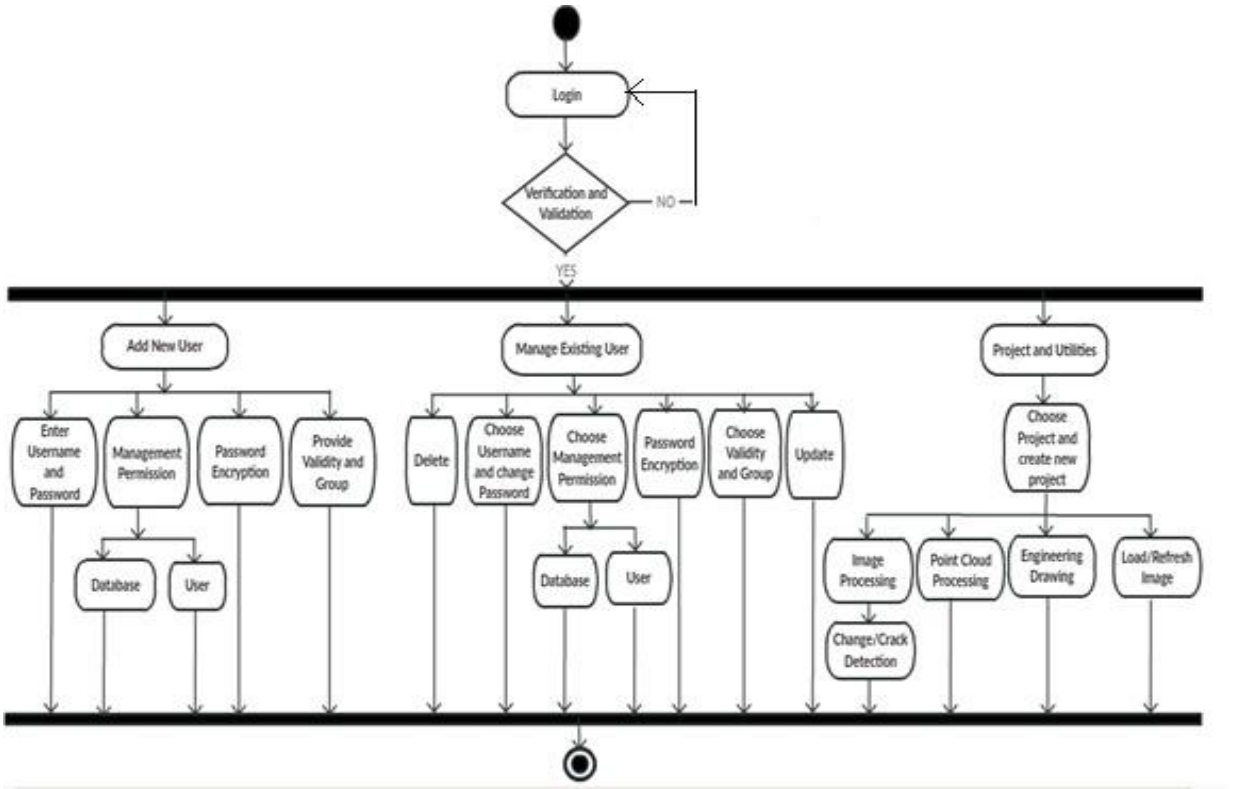

Fig.4 Activity Diagram for Admin

USER:

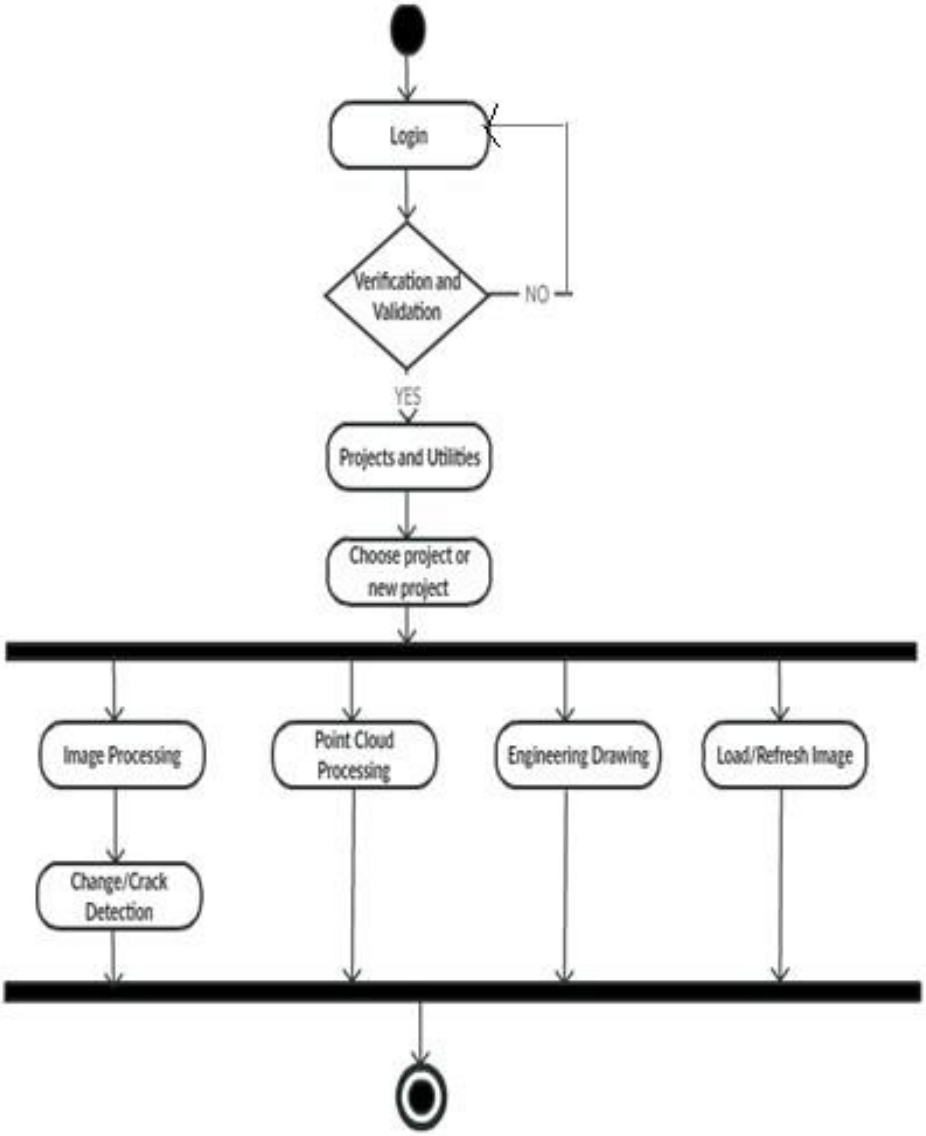

Fig.5 Activity Diagram for User

7.5 SEQUENCE DIAGRAM:

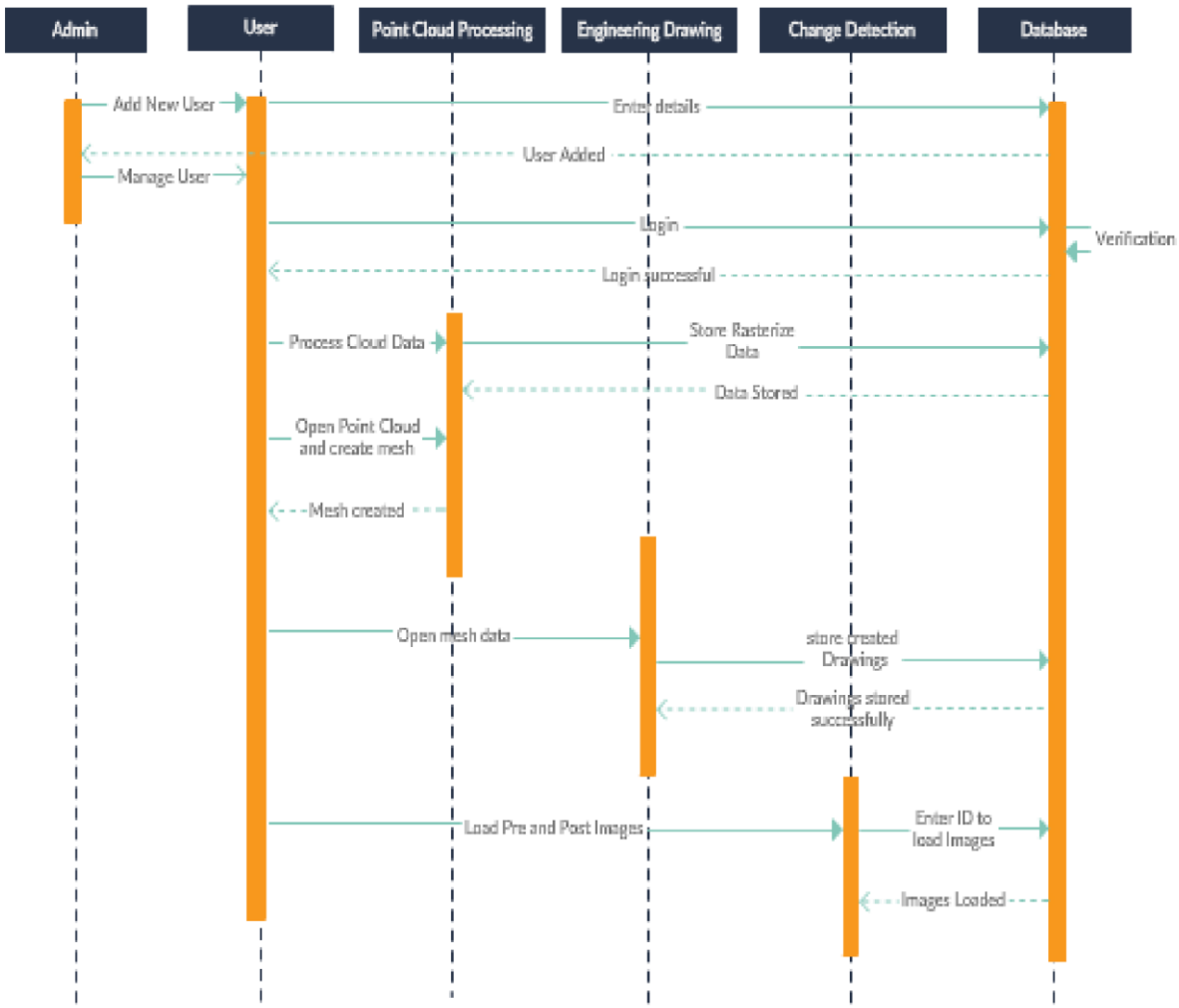

Fig.6 Sequence Diagram showing various processes

CRACK DETECTION:

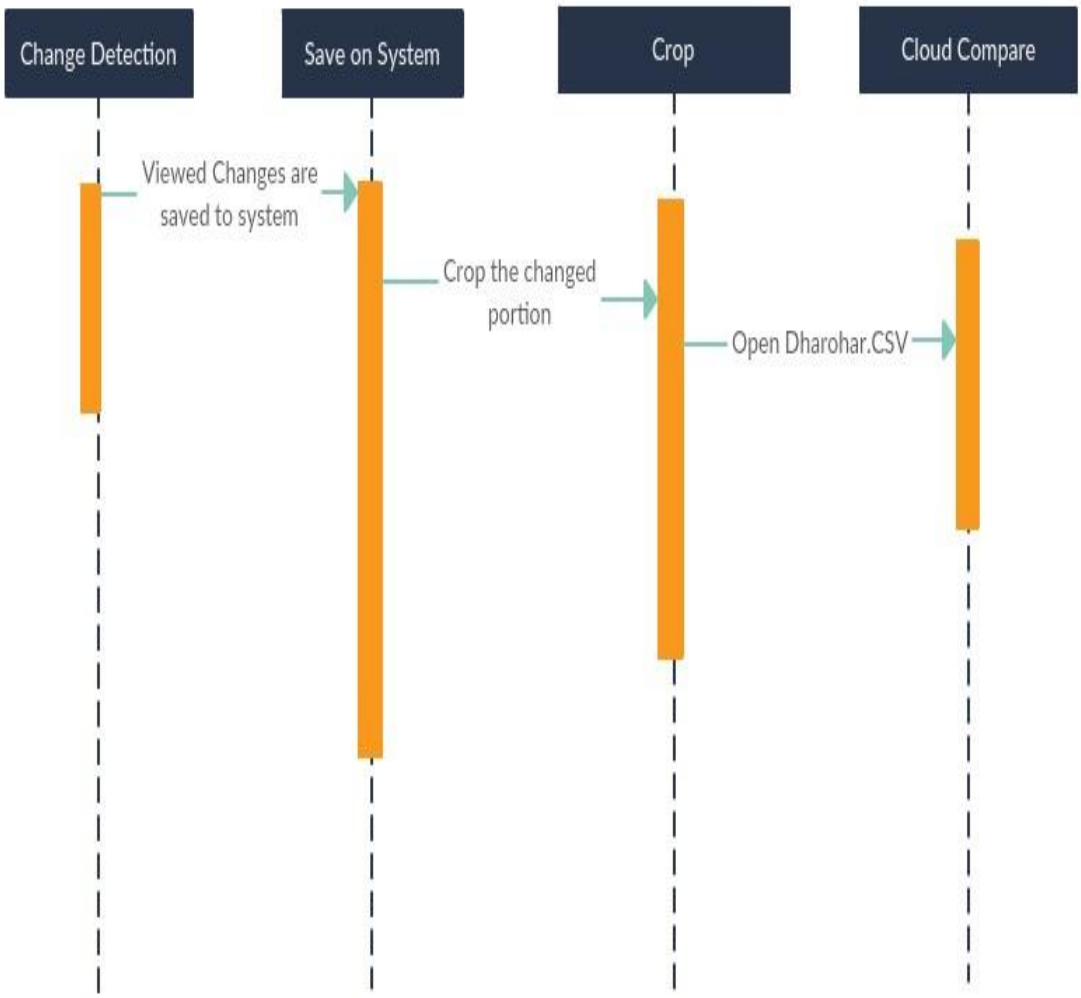

Fig.7 Sequence Diagram for Crack Detection

7.6 FLOW CHART:

A) CREATE RASTER DATA AND ENGINEERING DRAWING:

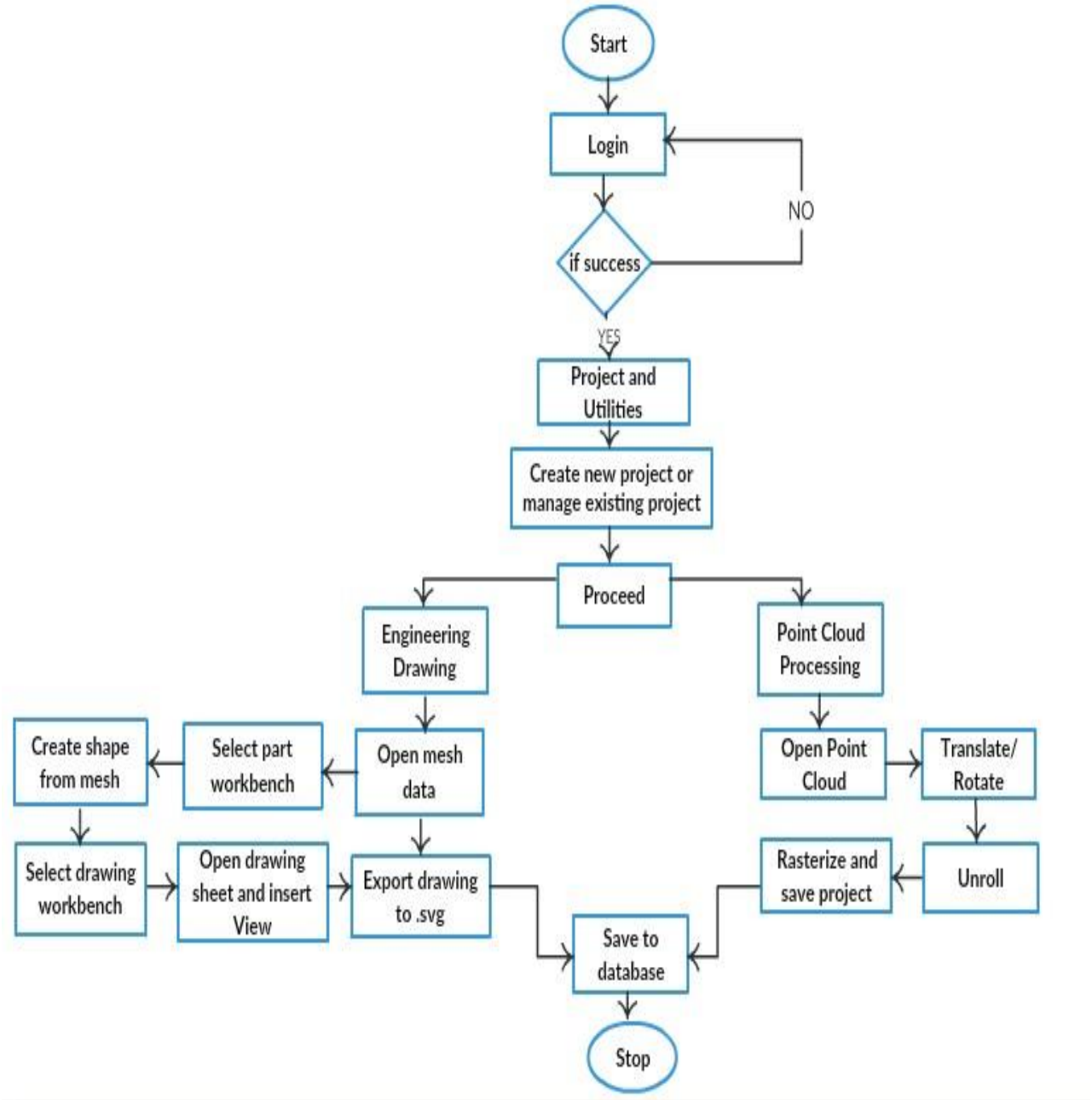

Fig.8 Flow Chart showing Engineering Drawing and Point Cloud Processing

B) CRACK DETECTION

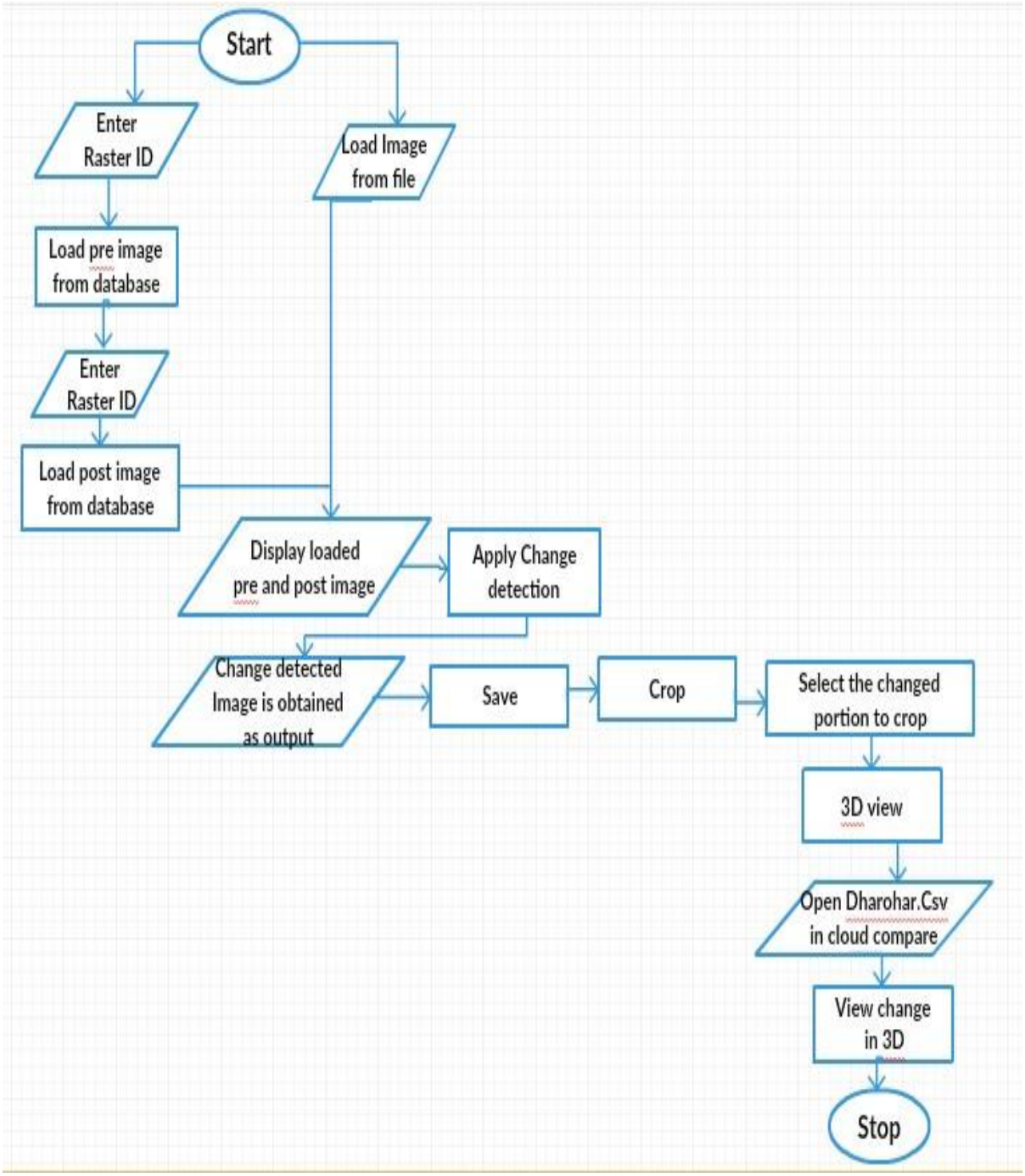

Fig.9 Flow Chart showing crack detection

8.USER INTERFACE :

The user can select from any of the given languages

Fig. 10 : Language Selection

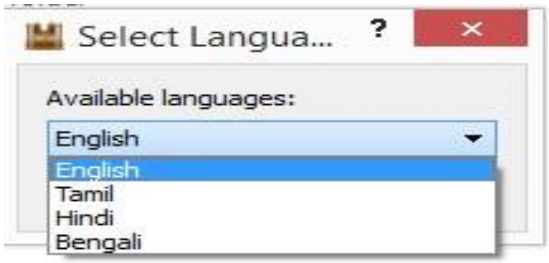

Fig 11: Authenticating For logging in to the application

Fig 12 : Adding New User

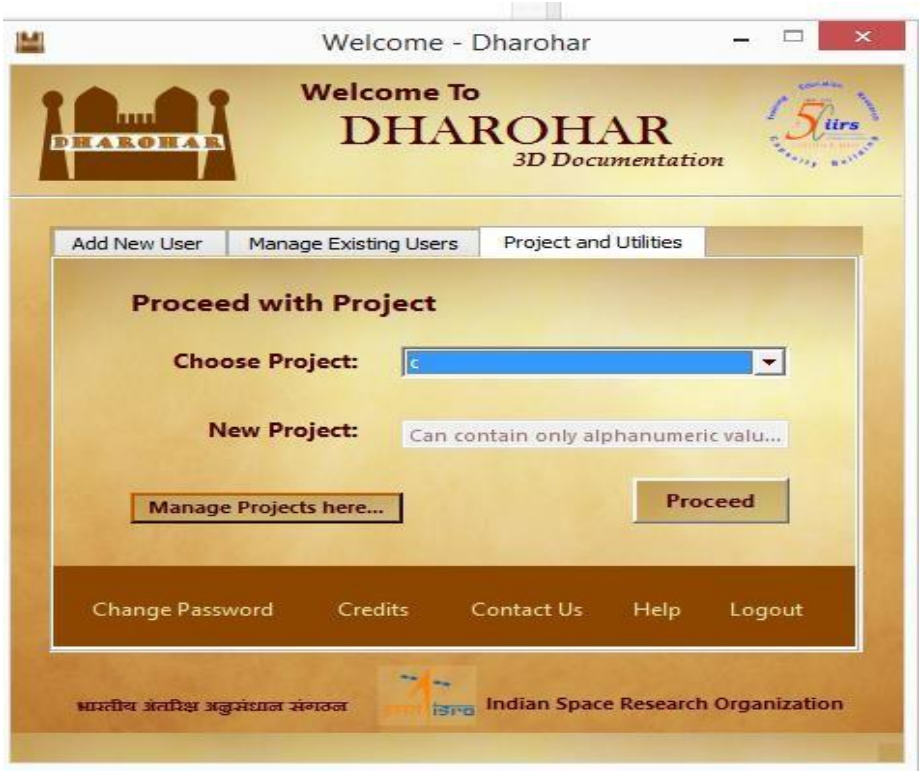

Fig 13 :Choose from existing project

Fig 14: Manage Existing User

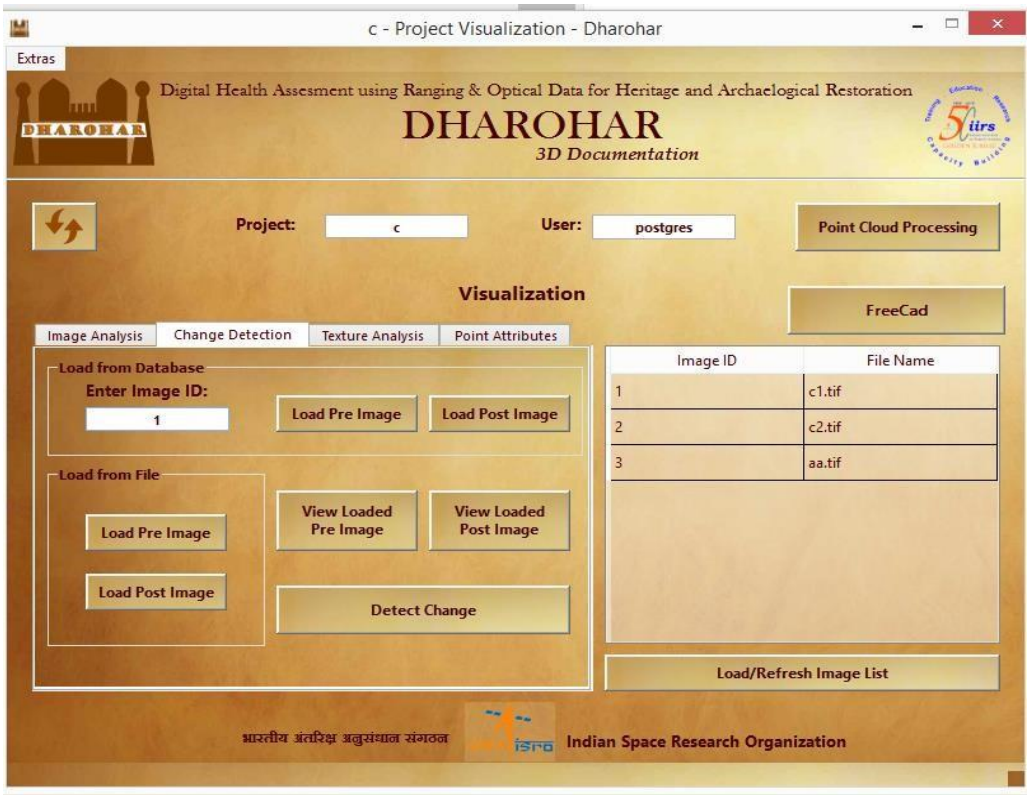

Fig 15: Enter Image ID and Load Pre Image

Here, first the user will load the image list from the database. The ID of pre and post image are entered in ‘Enter Image ID’ cell and both images are loaded. The changes are detected by clicking ‘Detect Change’ and are depicted in Fig:17.

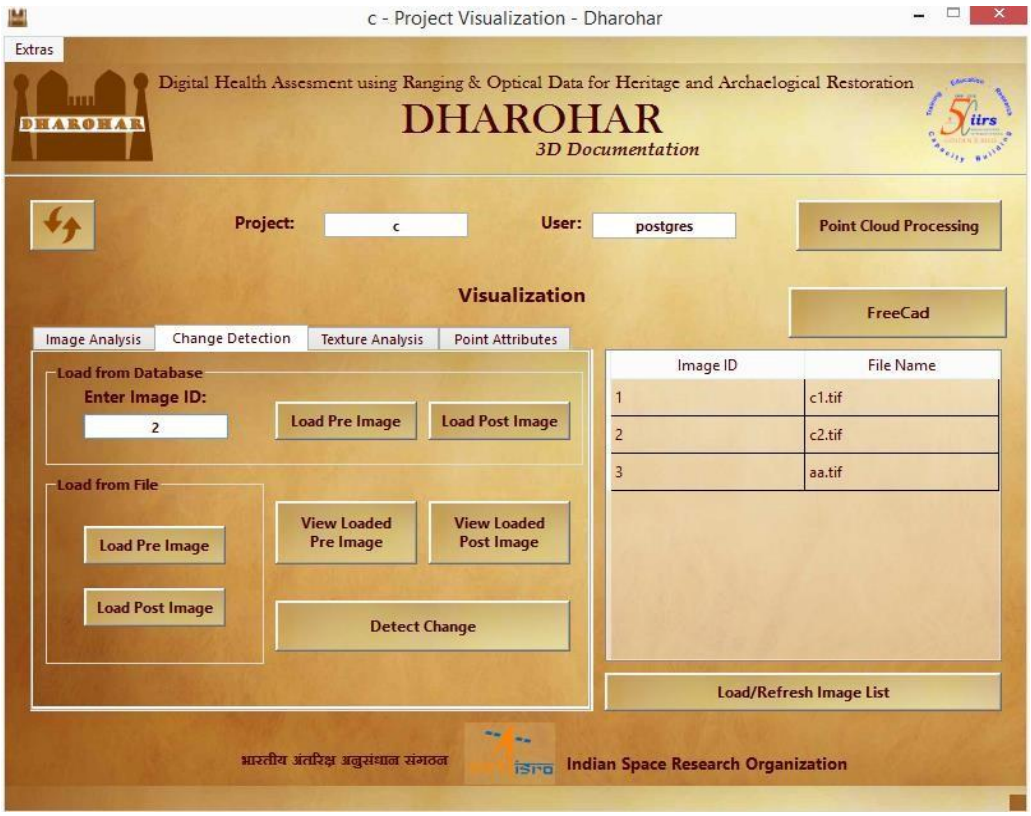

Fig 16: Enter Image ID and Load Post Image

Fig 17: Change Detected displayed inside square

Here, the user needs to crop the portion to view it in 3D. For this the change is first saved to a location and then the CROP is clicked. The user will make a rectangular selection on the displayed change and will click on 3DVIEW which will open the Cloud Compare window. A file name Dharohar.csv is created on desktop and the user needs to open the same to view the change in 3D. The sreenshot for the same is shown in Fig:19.

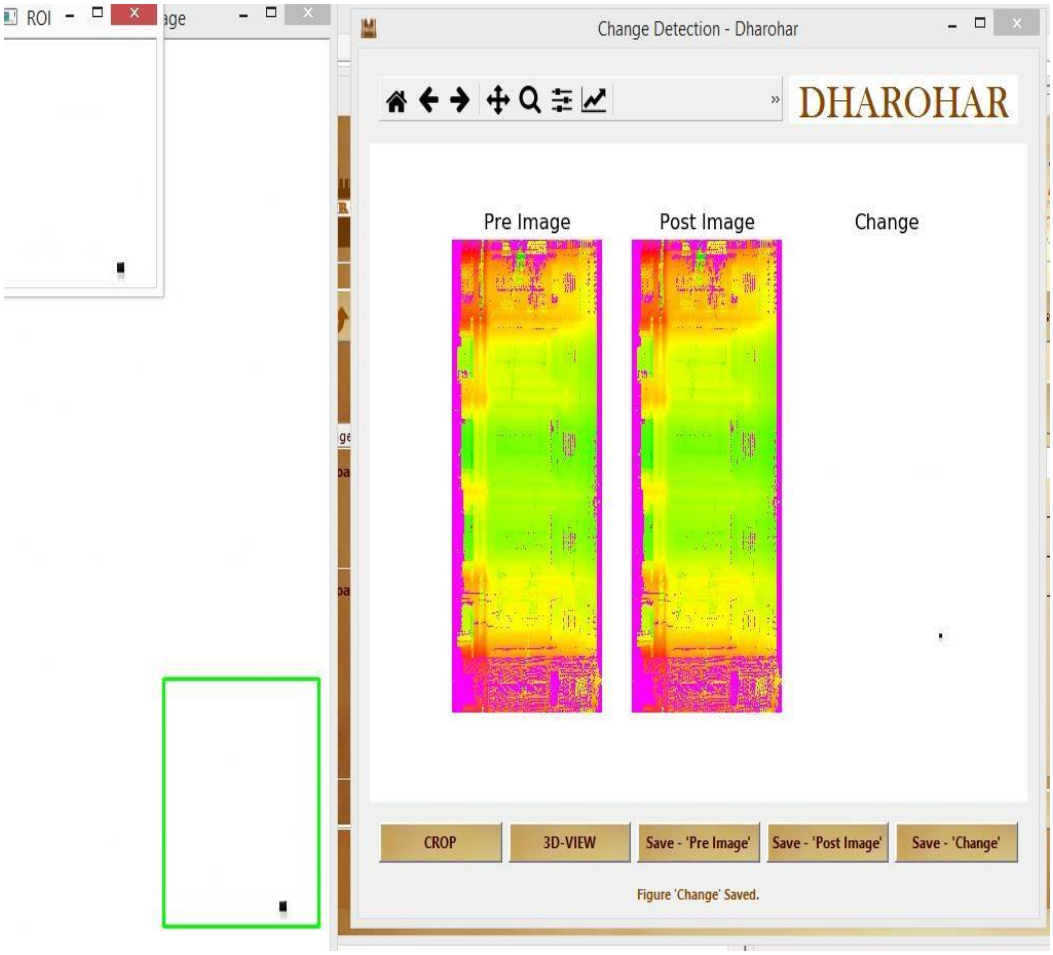

Fig 18: Select the changed portion to crop

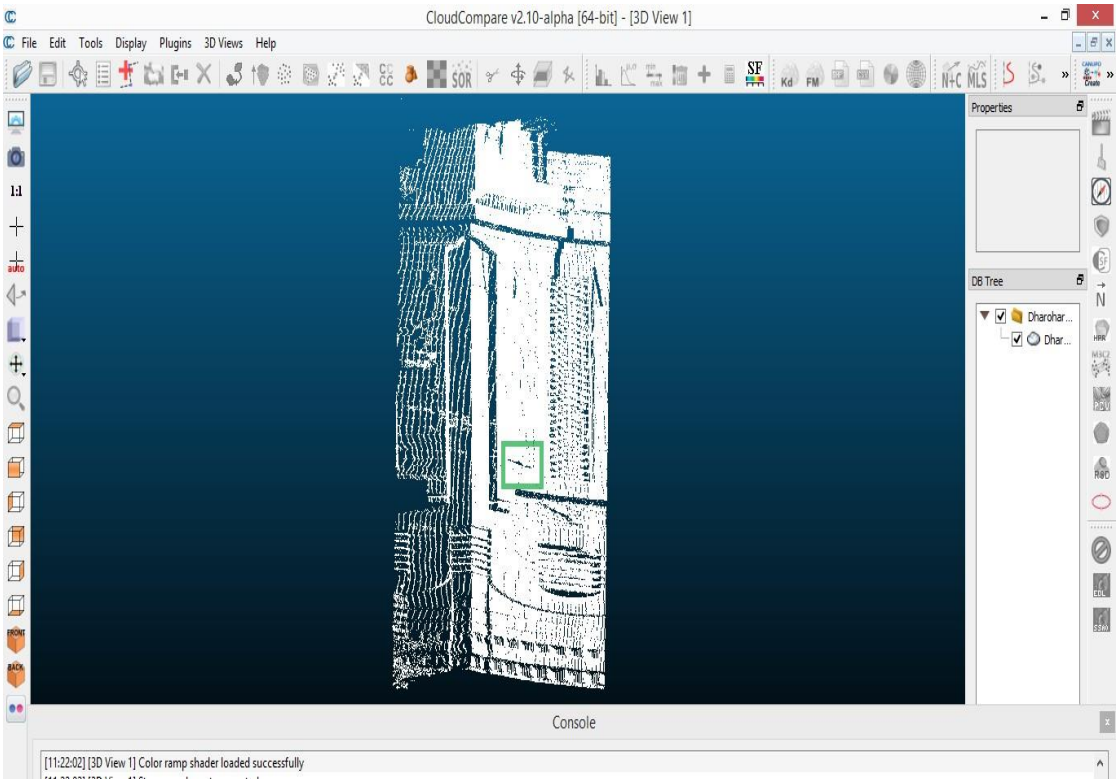

Fig 19: Crack is highlighted in green

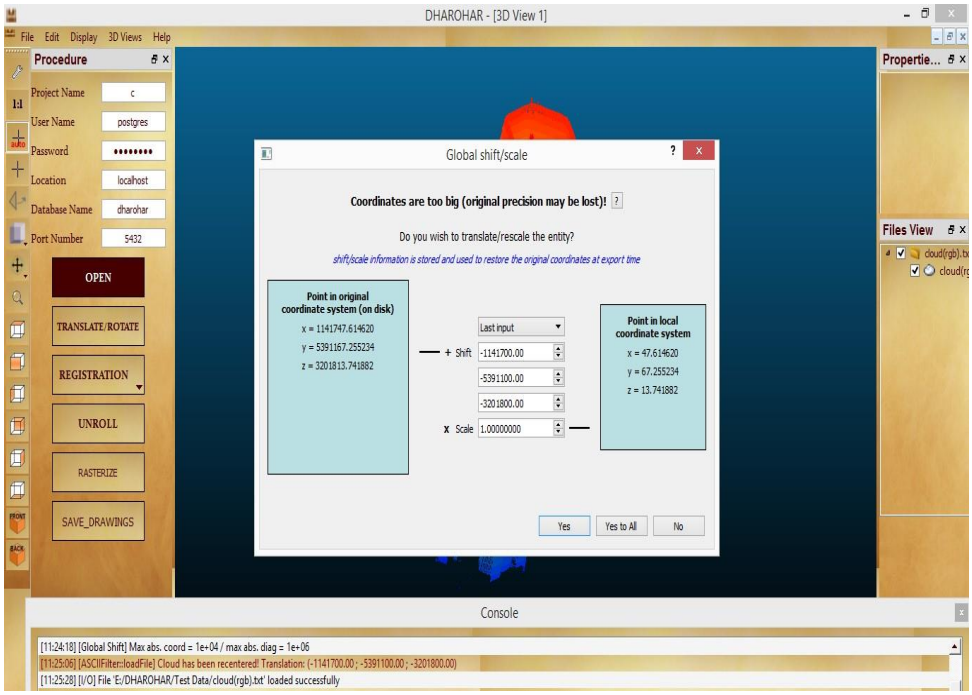

Fig 20: Open the point cloud

Open the original cloud as well as the cracked one. They will appear to be overlapped. Select both of them from the tree view and click Translate/Rotate and rotate to get the top view so as to unroll it properly. The view after rotation is shown in Fig: 22.

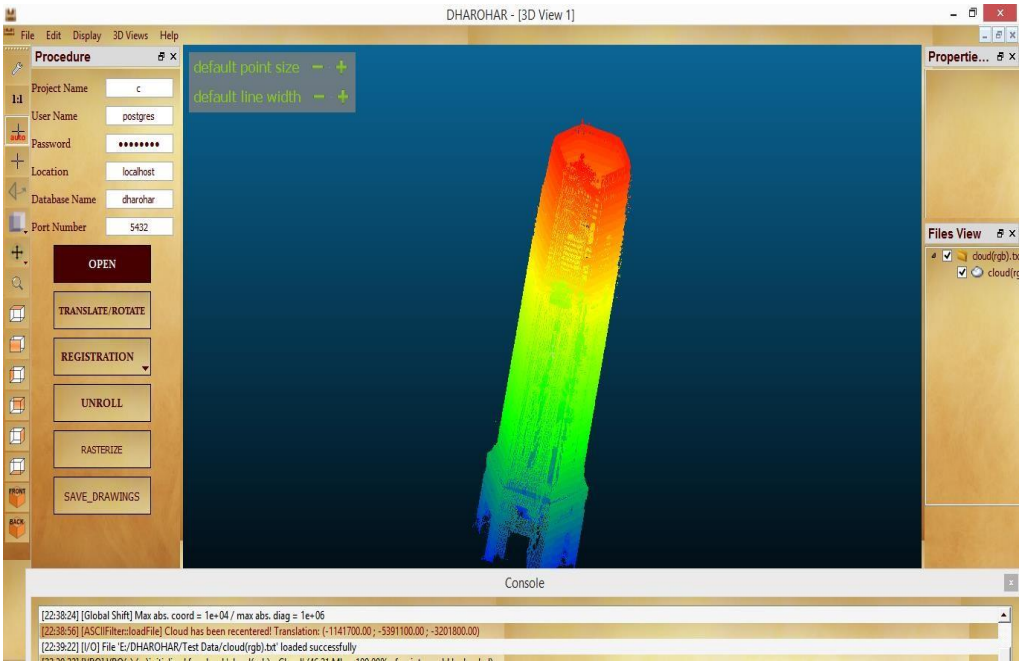

Fig 21: Opened point cloud

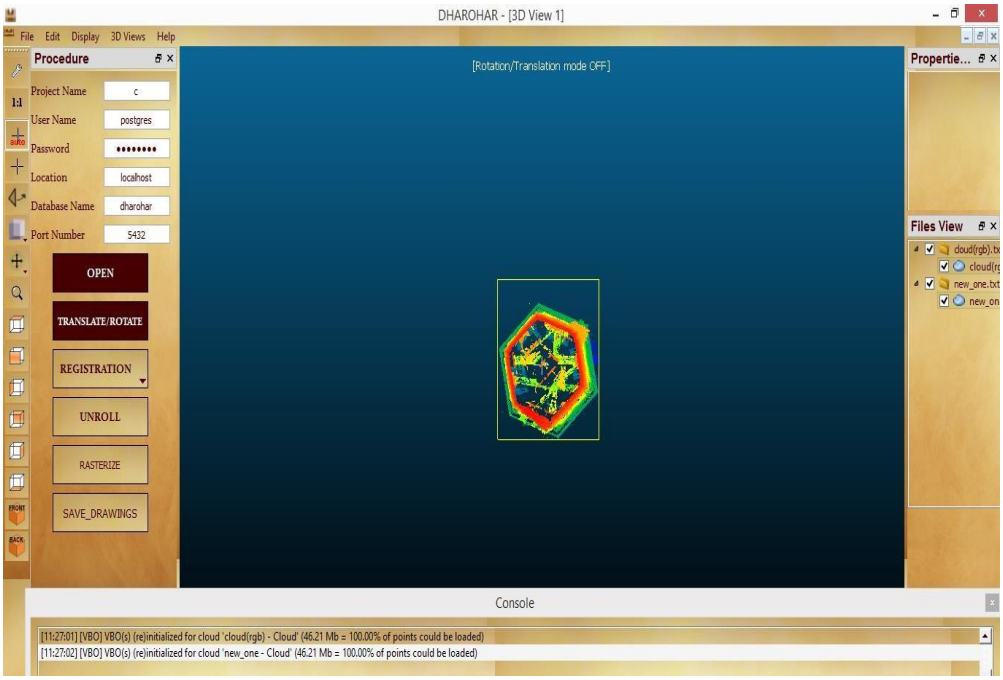

Fig 22:Translate/Rotate the clouds to unroll

Now separate the clouds by selecting any one cloud from tree view and Translate/Rotate by slightly displacing it. The two clouds are separated as shown in Fig:23.

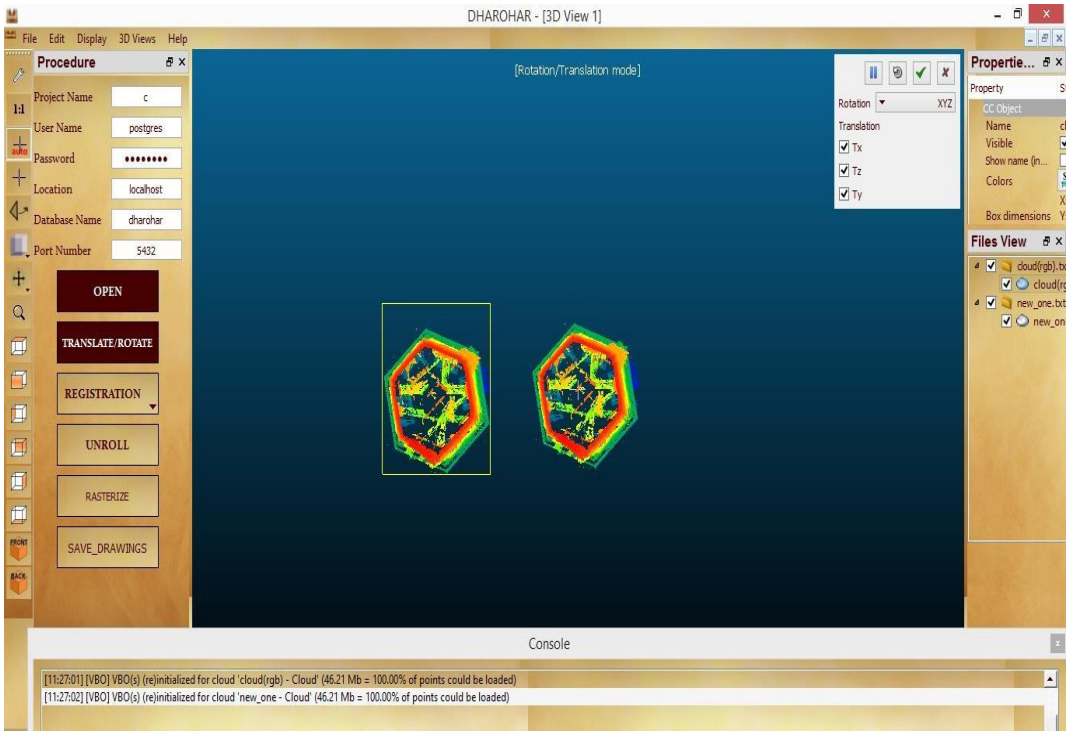

Fig 23:Separate the cloud by selecting one of them

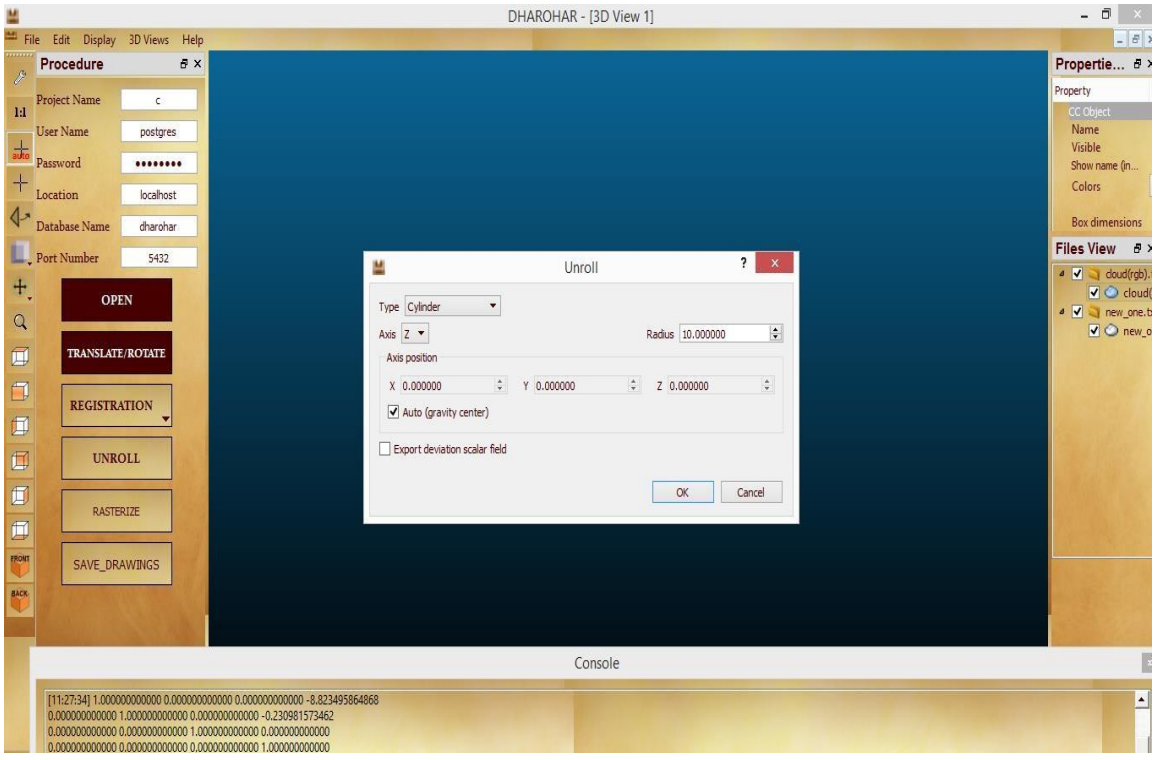

Fig 24:Unrolling in progress

Unrolling of point cloud is performed one by one. Select one at a time and click unroll.This will unroll the point cloud. The unrolled point clouds are shown in Fig: 27.

Fig 25:One cloud Unrolled

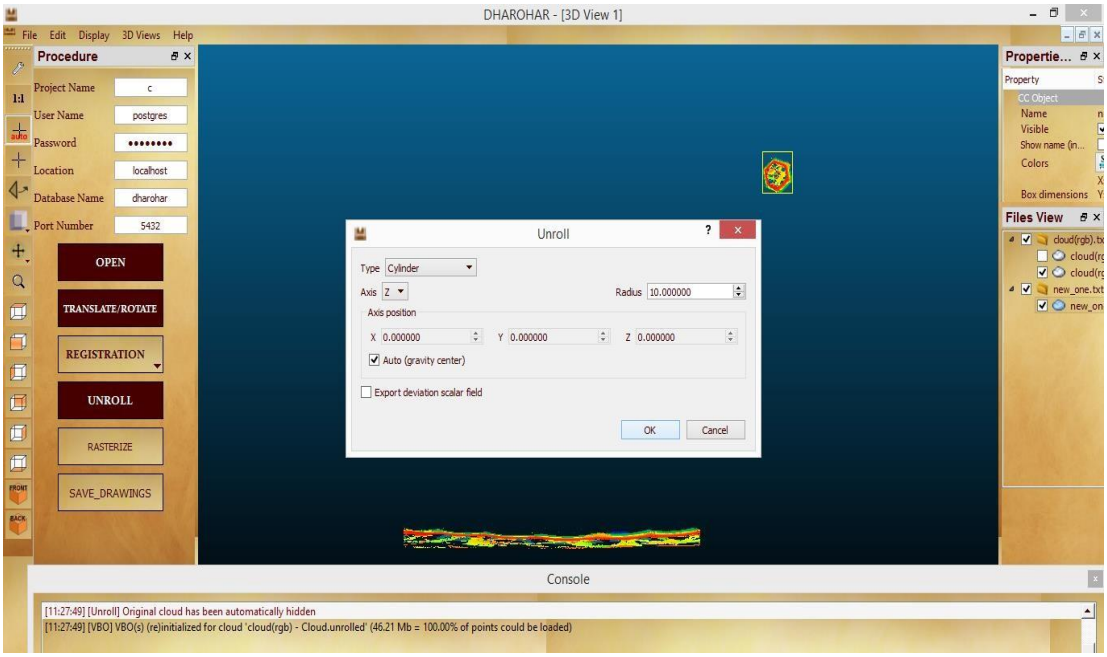

Fig 26: Select the second cloud and click unroll

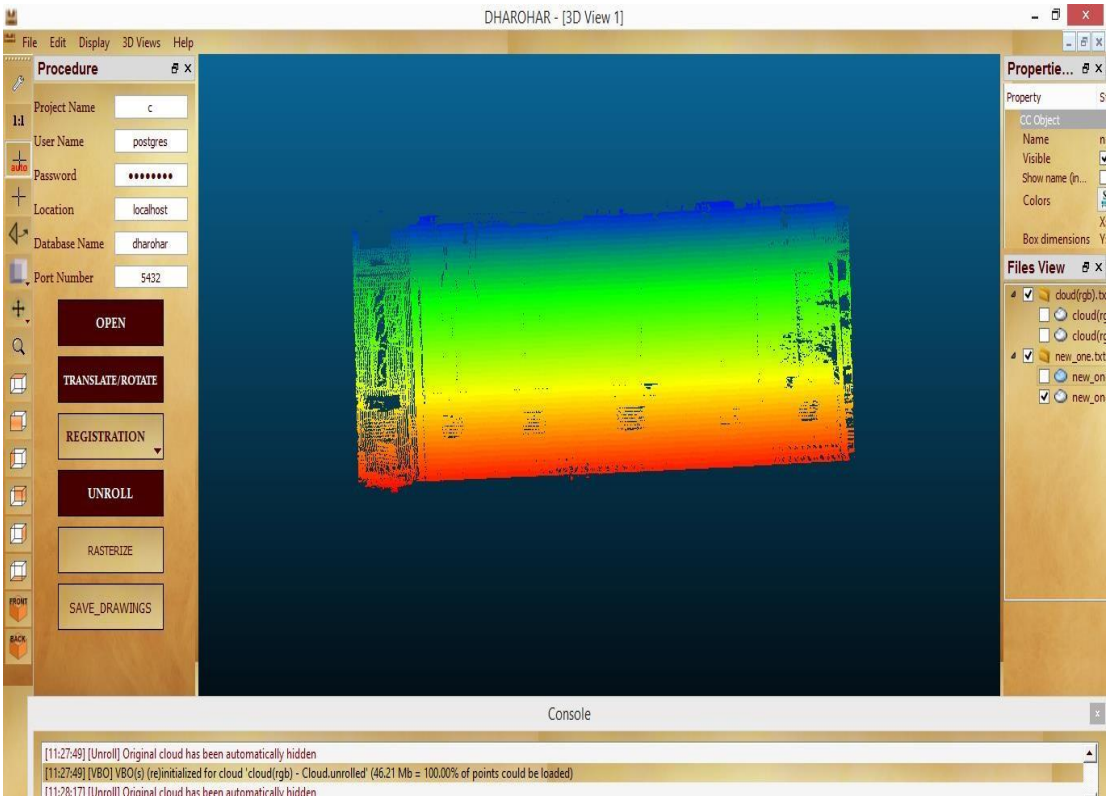

Fig 27:Unrolled point clouds

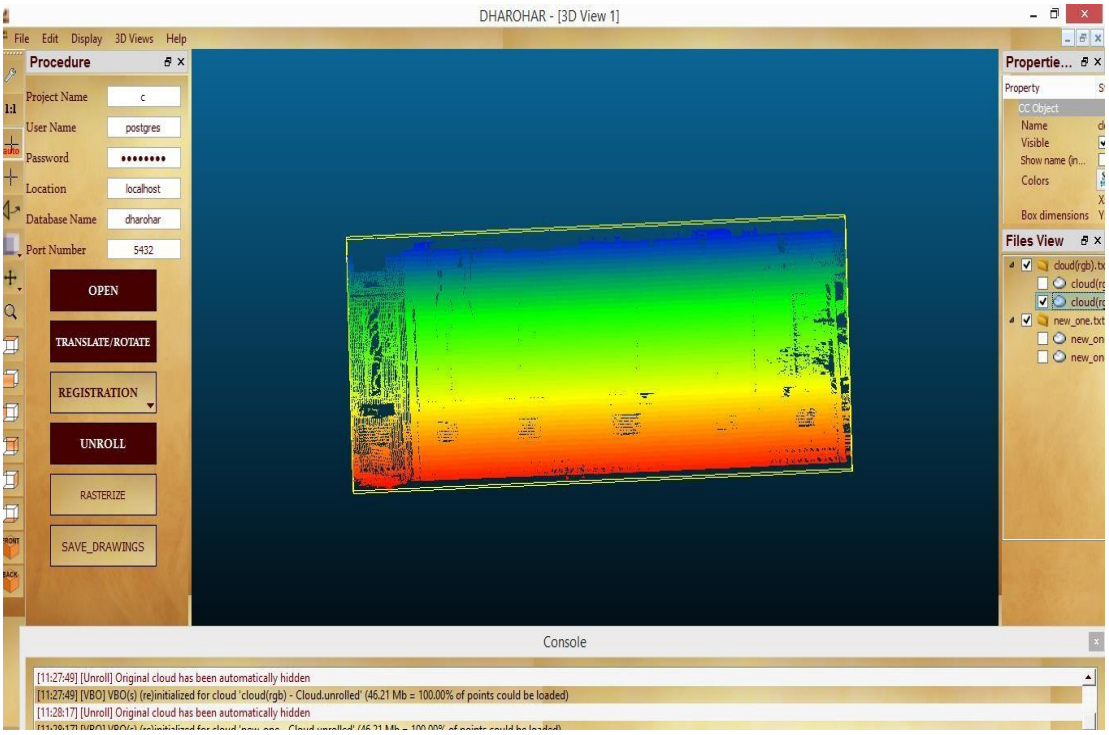

Fig 28: Select unrolled image to rasterize

This window will appear after clicking Rasterize. The user has to upgrade grid and set the projection direction to Y axis and the click Save Project and then raster image will be saved to database. The saved data is shown in Fig:30 & Fig:31.

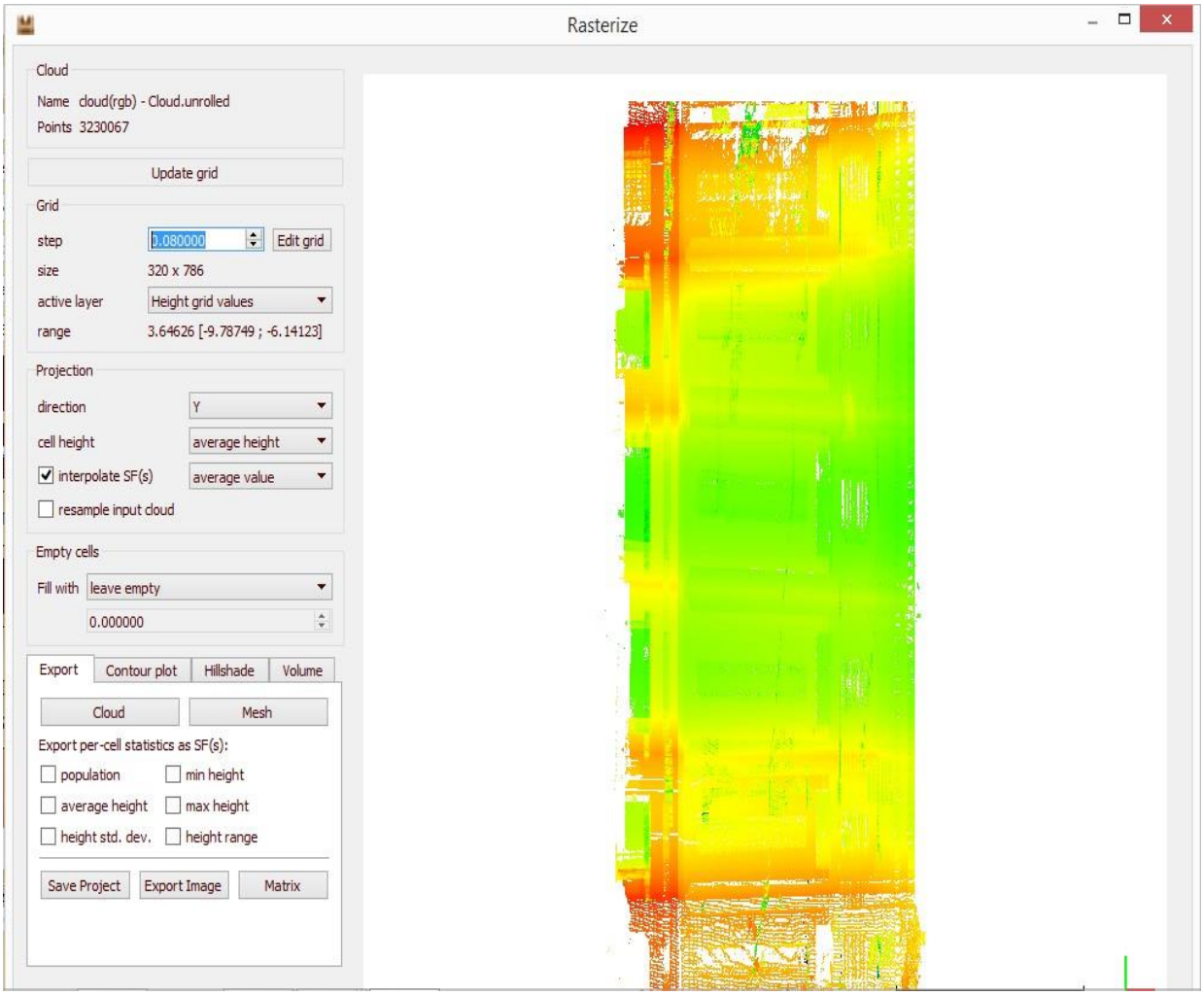

Fig 29:Save rasterize data to database

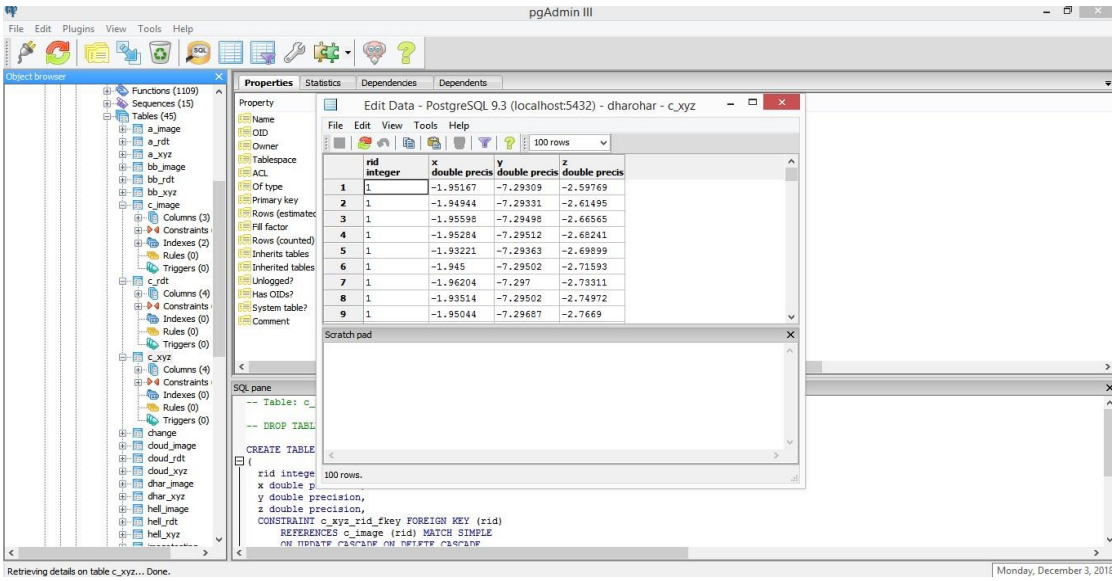

Fig30: save data

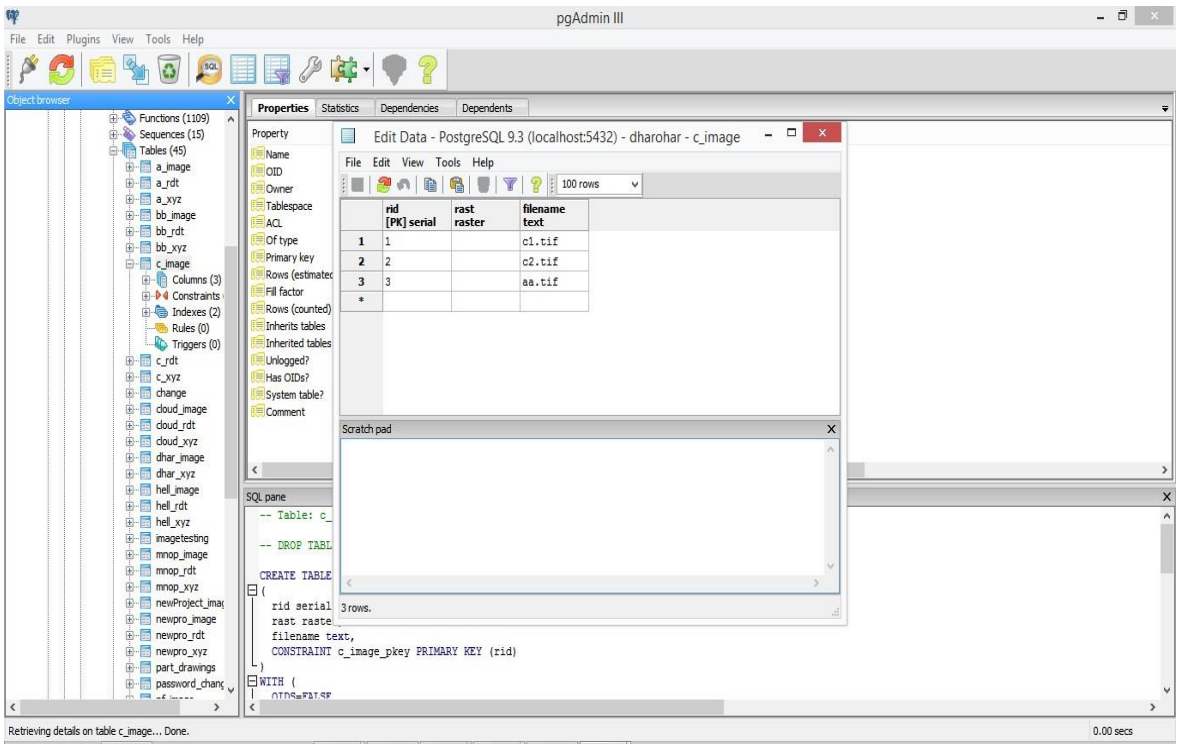

Fig 31: saved x,y,z coordinates of raster image

To create the drawings open FreeCAD by clicking on FreeCAD (refer fig 16). Open the mesh data(.stl format) , here a diamond shape data representing dome of the heritage site is taken into consideration.

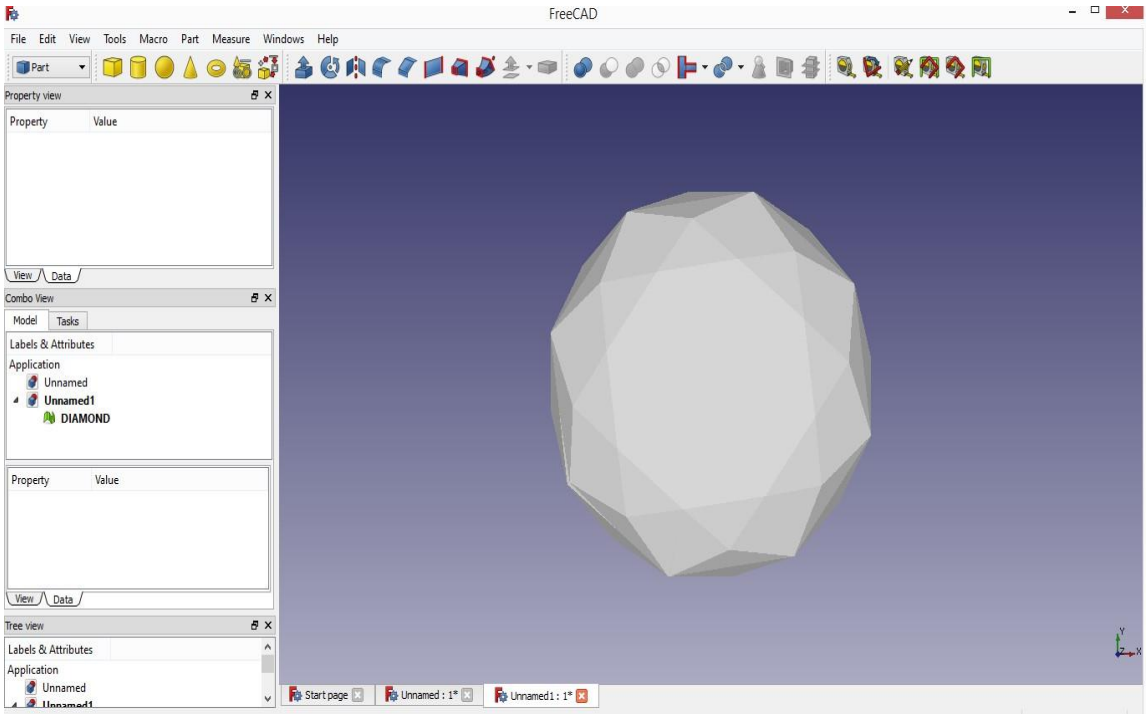

Fig 32: Open mesh data(.stl file)

Select Part Workbench and select part from menu bar to create shape from mesh.

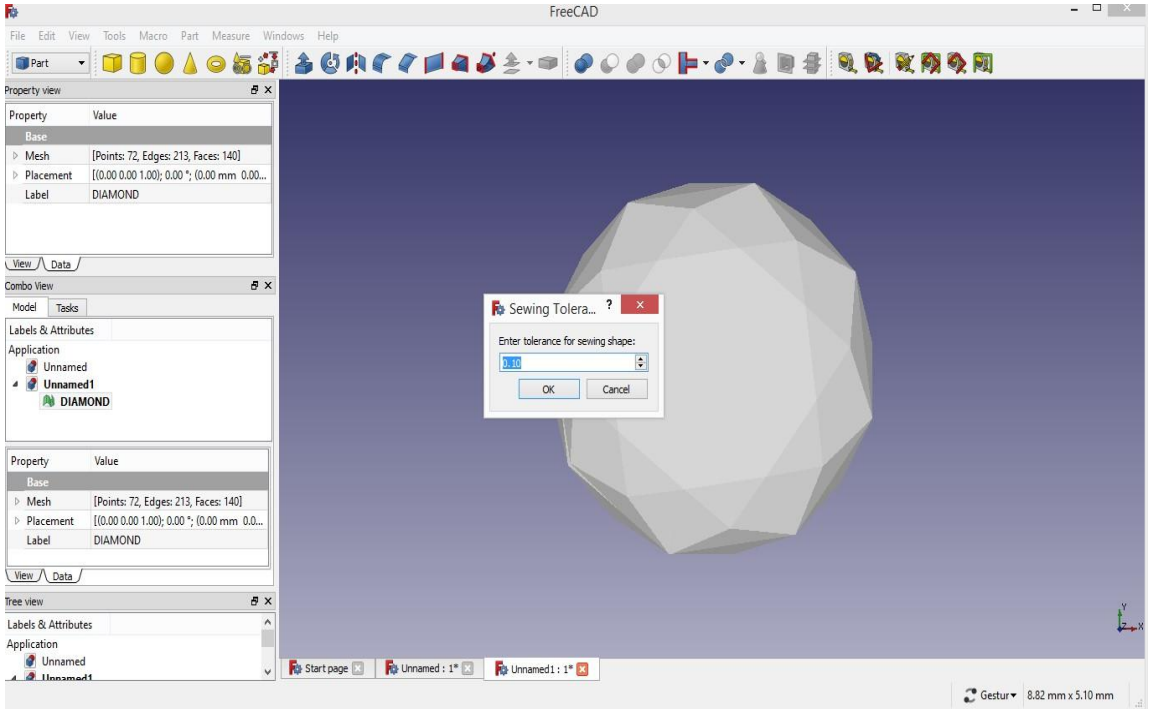

Fig 33: Select part workbench and create shape from mesh

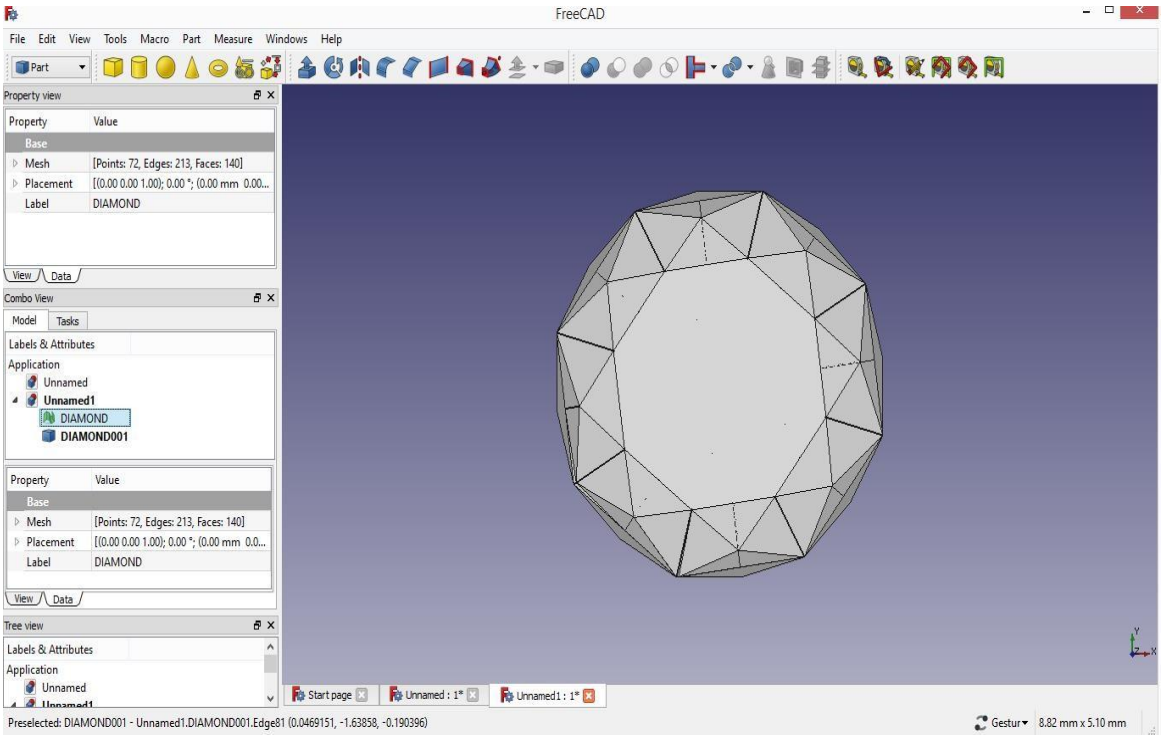

Fig 34:Shape created

Take Drawing Workbench and open a A4 sheet as shown in picture below.

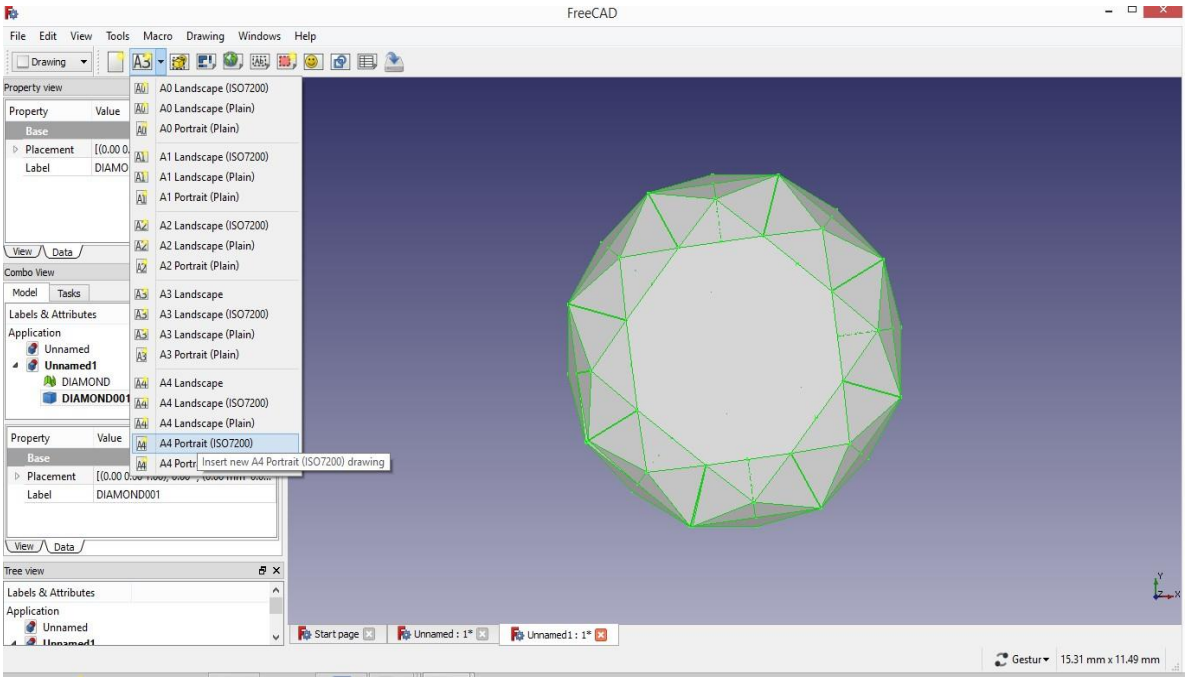

Fig 35: Select drawing workbench and take a drawing sheet

To get different views on drawing sheet select orthographic view from drawing tools and take views as depicted in the figure below.

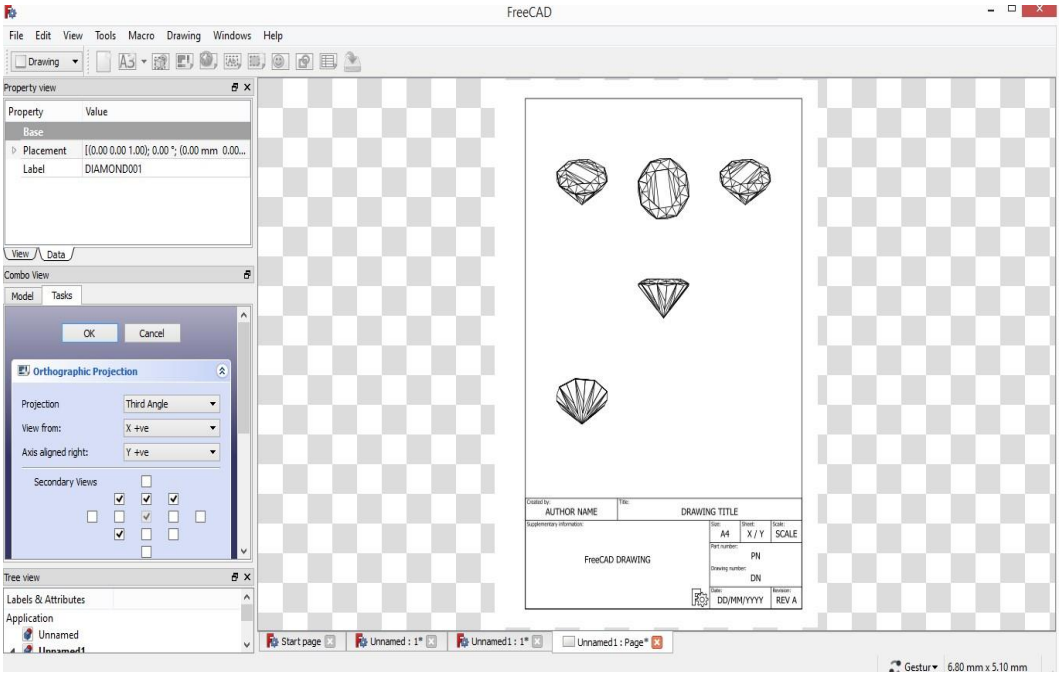

Fig 36:Take orthographic views and click ok

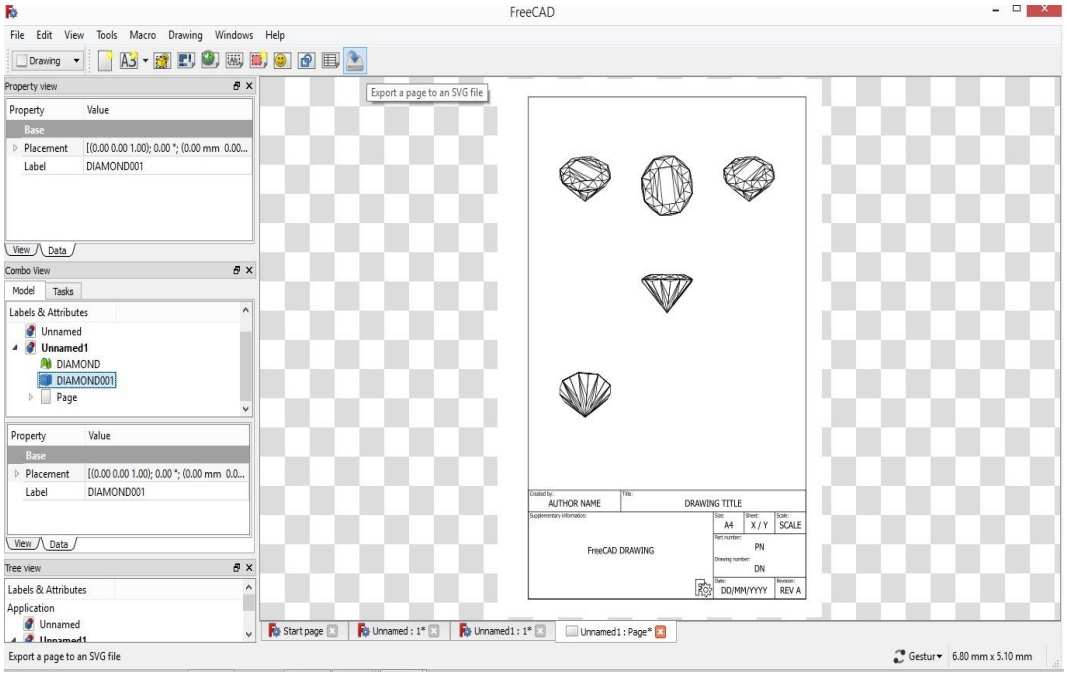

Fig 37: Drawings created

Export the drawings in .svg format

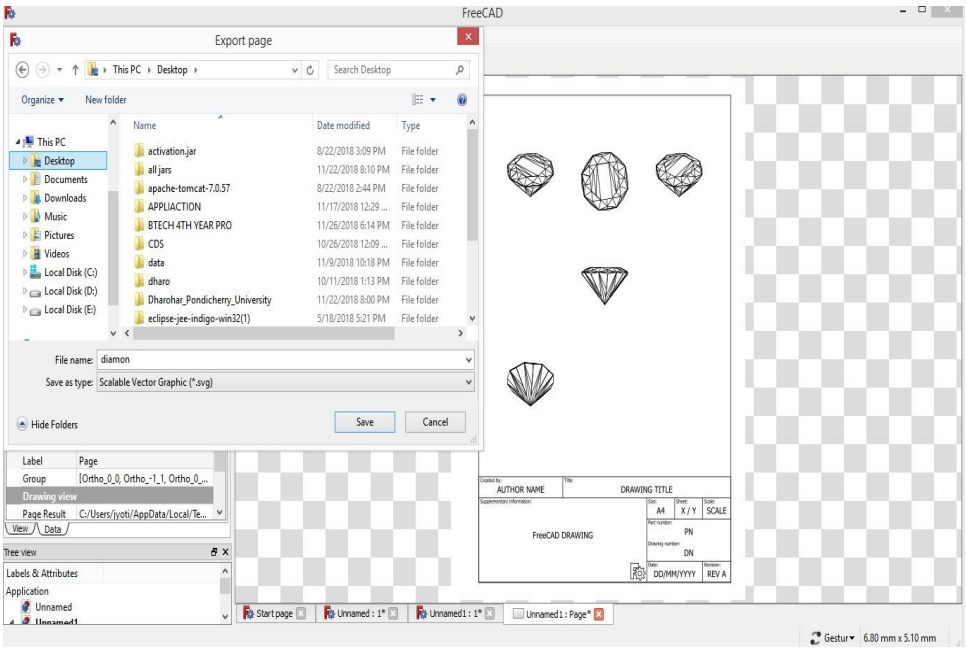

Fig 38: Export the sheet to .svg format

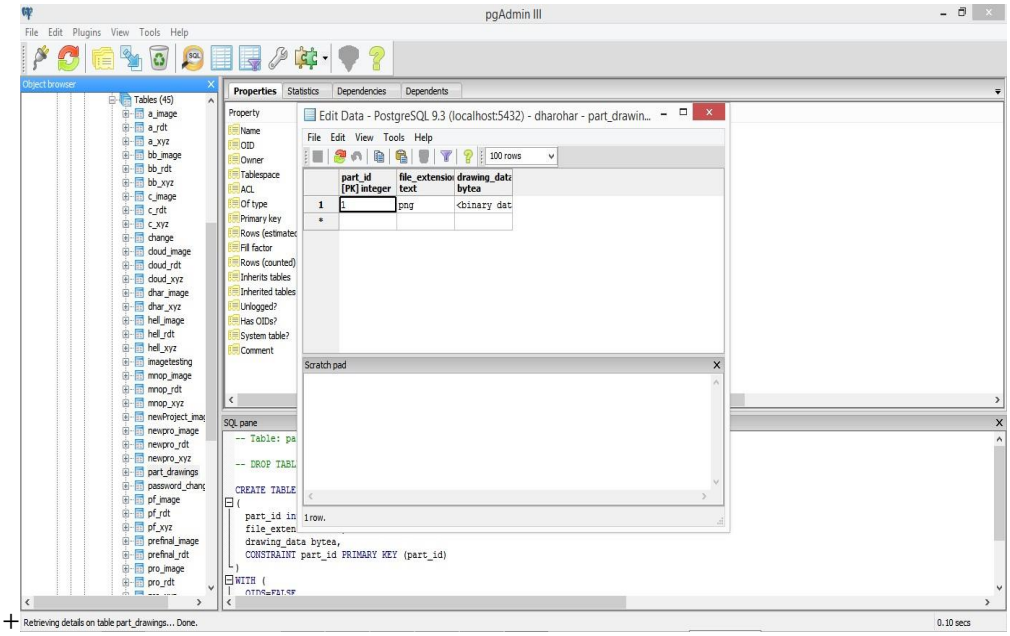

Fig 39: saved drawing sheet in .png format

9.TESTING:

Testing is the process of evaluating a system or its components with the intent to find whether it satisfies the specified requirements or not. In simple words, testing is executing a system in order to identify any gaps, errors, or missing requirements in contrary to the actual requirements.

UNIT TESTING

Unit testing is the testing of an individual unit or group of related units. It falls under the class of white box testing. It is often done by the programmer to test that the unit he/she has implemented is producing expected output against given input.
All the modules have been individually tested and all the test cases have passed successfully. And no defaults occur.

INTEGRATION TESTING

Integration testing is testing in which a group of components are combined to produce output. Also, the interaction between software and hardware is tested in integration testing if software and hardware components have any relation. It may fall under both white box testing and black box testing.
All the individual modules are integrated and tested together. All the test cases have passed successfully. And no defaults occur.

FUNCTIONAL TESTING:

Functional testing is the testing to ensure that the specified functionality required in the system requirements works. It falls under the class of black box testing.
Functions are tested by feeding them input and examining the output. Functional testing ensures that the requirements are properly satisfied by the application. Each functionalities of this application are tested by providing give set of inputs in order to know the actual behavior of the applications and thereafter comparing with the expected results as per the given specifications.
Functional testing mainly involves: Verifying

- user interfaces
- Verifying end to end work flows

Verifying correct data storing in the database. All the requirements are tested successfully.

SYSTEM TESTING:

System testing is a level of software testing where complete and integrated software is tested. The purpose of this test is to evaluate the system‘s compliance with the specified requirements. Usually software is only one element of a larger computer based system. Ultimately, software is interfaced with other software/hardware systems. System Testing is actually a series of different tests whose sole purpose is to exercise the full computer based system. The created standalone application is tested among various

systems with different windows Operating system and for both 32 nit and 64 bit systems.

ACCEPTANCE TESTING:

Acceptance testing is a level of software testing where a system is tested for acceptability. The purpose of this test is to evaluate the system‘s compliance with the business requirements and assess whether it is acceptable for delivery. Formal testing with respect to user needs, requirements, and business processes conducted to determine whether or not a system satisfies the acceptance criteria and to enable the user, customers or other authorized entity to determine whether or not to accept the system.

10.CONCLUSION

In recent days, due to high increase in pollution, high rate of damages in our heritages are noticed which is even rising at an alarming rate. These heritages are the most precious assets a country has and needs severe maintenance to keep them sustained for coming eras. The maintenance is not possible for humans to check and do on a regular basis, manually. This gave rise to the concept for our application, ----
DHAROHAR.

There were many applications already available in the market to do so but in order to perform all the required processing completely, the need was to utilize multiple applications. The transfer of data from one application to another, causes loss of data and a lot of inconveniences. Our application ran over all those issues and looked forward towards one standalone application, to perform all the processing in one platform.

The application is thus a one stop solution to all the requirements for the regular survey and maintenance.

RECOMMENDATION

- It is recommended to create a process to open Dharohar.csv file directly when the change is viewed in 3D.
- Create untitled.exe for the customised cloud compare to save the changes.
- FreeCAD takes a lot time to process the huge mesh data so it is recommended to integrate a software that can take the huge mesh data as input and gives the created shape as output.

11.REFERENCES

- github.com/CloudCompare/CloudCompare
- www.freecadweb.org/wiki/Points_Module
- sourceforge.net/projects/free-cad/
- cx-freeze.readthedocs.io/en/latest/overview.html
- docs.scipy.org/doc/numpy/reference/generated/numpy.array.html
- opencv_python_tutroals.readthedocs.io/en/latest/py_tutorials/py_bindings/py_table_of_contents_bindings/py_table_of_contents_bindings.html