Hybrid Technique For Three Dimensional Modeling From Close Range Laser Scanner's Point Clouds

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INTRODUCTION

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Object

Scanning

Modeling

3D model

Registration /Alignment
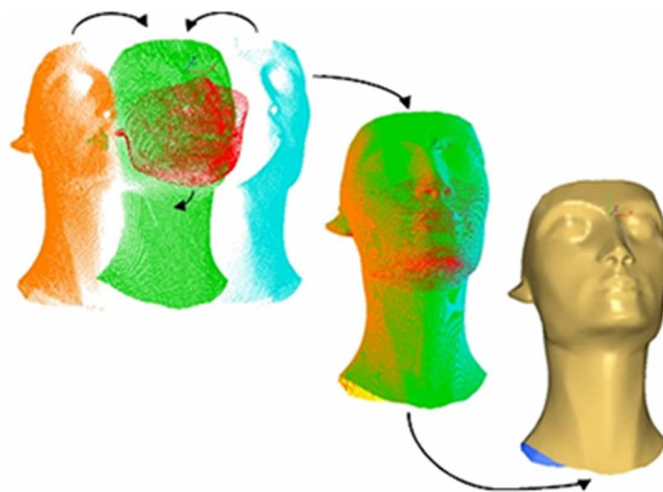
Sources: http://mathnathan.com/2012/03/registering-two-point-clouds/

Surface Reconstruction

Point cloud data   Reconstructed surface
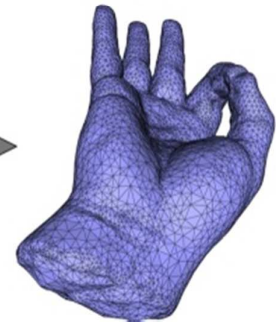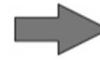
Sources: http://www.cse.ohio-state.edu/~tamaldey/geohome.html

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Software for point clouds processing

- Open Source : MeshLab, PCL, VTK,
- Commercial Software: RapidForm , FaroScene , Kubit ,Geomagic.........
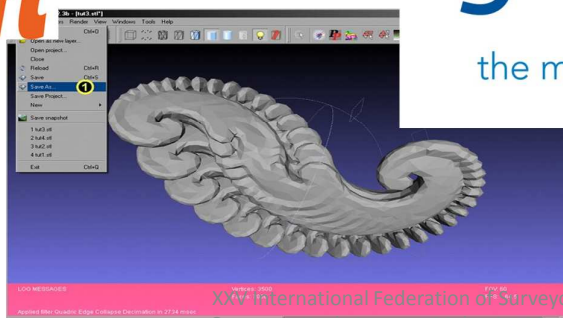
The Hybrid Technique

- The algorithms used to generate 3D model from laser scanner
- The pipelines for 3D modeling from laser scanner point clouds
- Towards automation of 3D modeling process

REVIEWS

Point cloud Registration

- Iterative Closet Point (ICP):Besl and Mckay,1992;Chen and Medioni,1992; Zhang,1992

- Variation of ICP algorithm: Rusinkiewicz and Levoy ,2001; Greenspan and Godin, 2001; Gruen and Arka, 2005

- Least Square Method : Gruen and Arka,2005

- …………

Surface Reconstrcution

- The Crust algorithm (Amenta and Bern,1999)

- The COCONE algorithm (Amenta et al ,2002)

- Tight COCONE algorithm (Dey and Goswami,2003)

- The PowerCrust algorithm (Amenta et al ,2000 & 2001)

- ……………

3D MODEL ACQUISITION PIPELINE

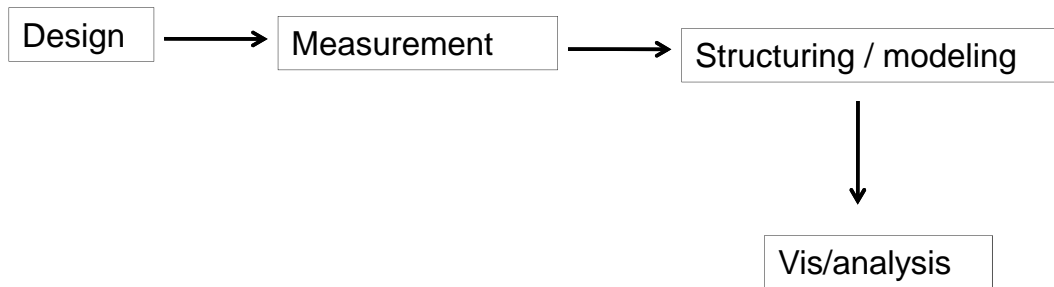innovative ● entrepreneurial ● global

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Bernardini and Rushmeier (2002)

Range image

Intensity image

Registration

Texture to geometry registration

Line of sight error compensation

Computation of illumination invariants

Integration of scans into a single mesh

Postprocessing and parameterization

Texture map reconstruction

Textured Model

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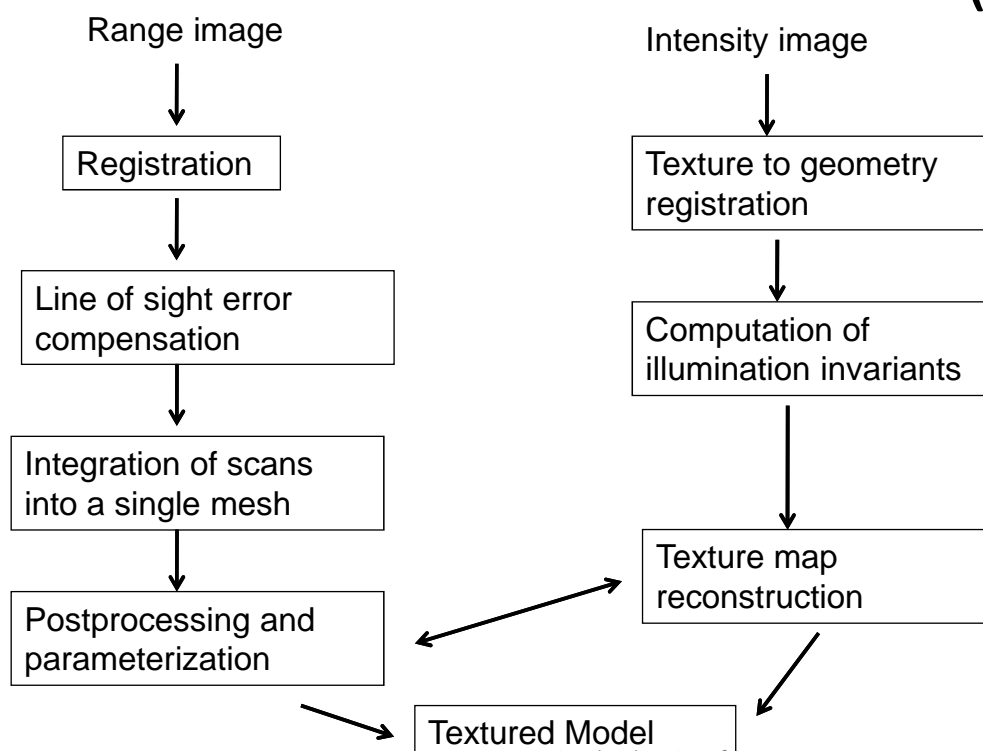
3D Modeling by using photogrammetric technique (Gruen,2002)

```
┌─────────┐      ┌──────────────┐      ┌──────────────────────┐
│ Design  │ ───→ │ Measurement  │ ───→ │ Structuring / modeling│
└─────────┘      └──────────────┘      └──────────────────────┘
                                                   │
                                                   ↓
                                         ┌──────────────┐
                                         │ Vis/analysis │
                                         └──────────────┘
```

RapidForm (commercial software)
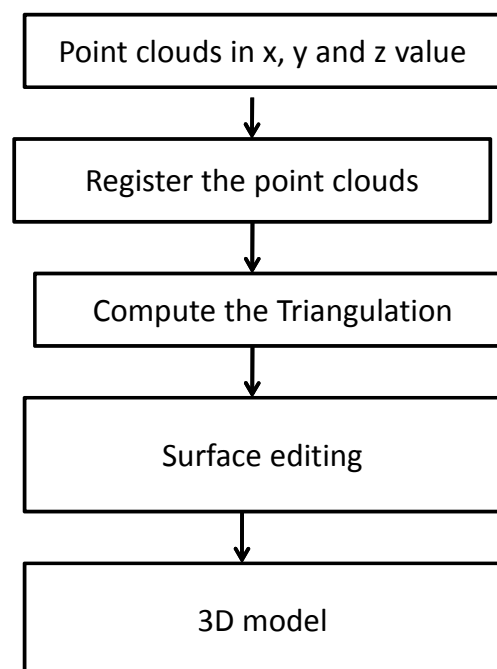
```
┌──────────────────────────────────┐
│  Point clouds in x, y and z value │
└──────────────────────────────────┘
                 │
                 ↓
┌──────────────────────────────────┐
│      Register the point clouds    │
└──────────────────────────────────┘
                 │
                 ↓
┌──────────────────────────────────┐
│      Compute the Triangulation    │
└──────────────────────────────────┘
                 │
                 ↓
┌──────────────────────────────────┐
│          Surface editing          │
└──────────────────────────────────┘
                 │
                 ↓
┌──────────────────────────────────┐
│             3D model              │
└──────────────────────────────────┘
```

HYBRID 3D MODELING TECHNIQUE

Hybrid 3D Modeling Technique

```
┌─────────────────────────────────────┐
│   Point clouds in x, y and z value   │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│    Register the point clouds using   │
│      modified ICP algorithm          │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│      Compute the AMLS surface        │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│    Apply the Delaunay/Voronoi        │
│    based surface reconstruction      │
│              algorithm               │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│              3D model                │
└─────────────────────────────────────┘
```
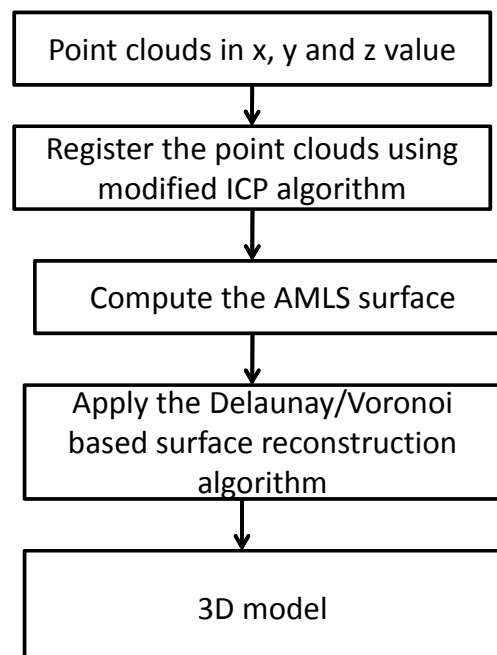
The modification of ICP algorithm
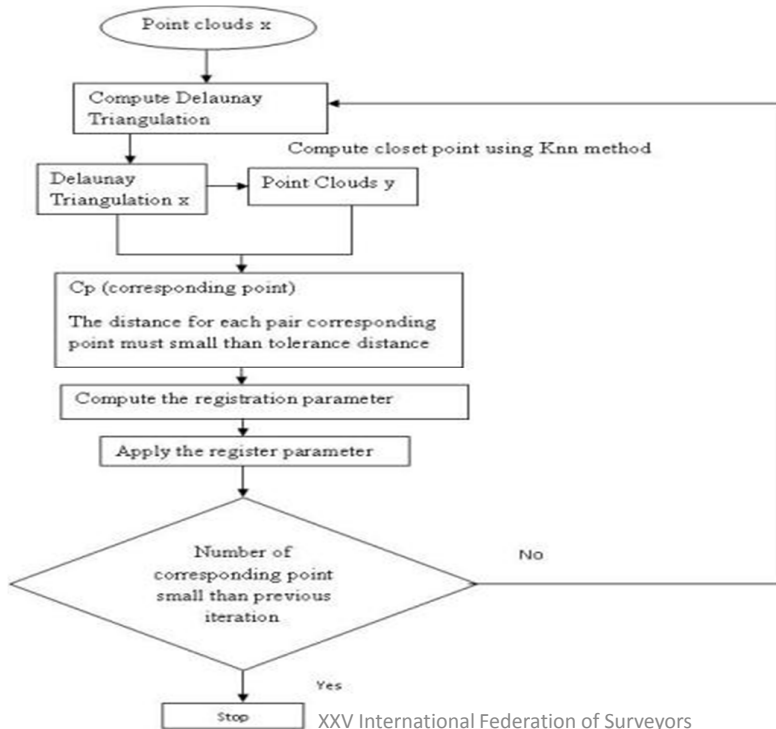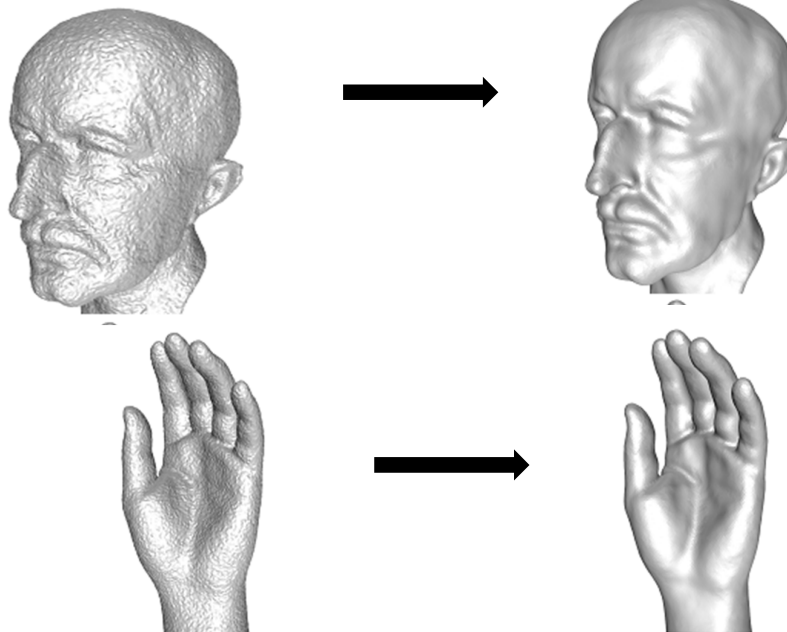
AMLS Surface

Original surface   AMLS suraface

Sources: Dey and Sun(2005). An Adaptive MLS Surface for Reconstruction with Guarantees

Surface reconstruction algorithm

```
┌─────────────────────────┐          ┌─────────────────────────┐
│ Compute the Delaunay    │          │                         │
│ Triangulation of the    │ ──────▶  │ Compute the feature ball│
│ point clouds            │          │                         │
└─────────────────────────┘          └─────────────────────────┘
                                                  │
                                                  ▼
┌─────────────────────────┐          ┌─────────────────────────┐
│ Retain the point on     │ ◀──────  │ Separate the outer and  │
│ outer ball              │          │ inner feature ball      │
└─────────────────────────┘          └─────────────────────────┘
            │
            ▼
┌─────────────────────────┐
│ Compute the surface     │
│ from these  points      │
└─────────────────────────┘
```
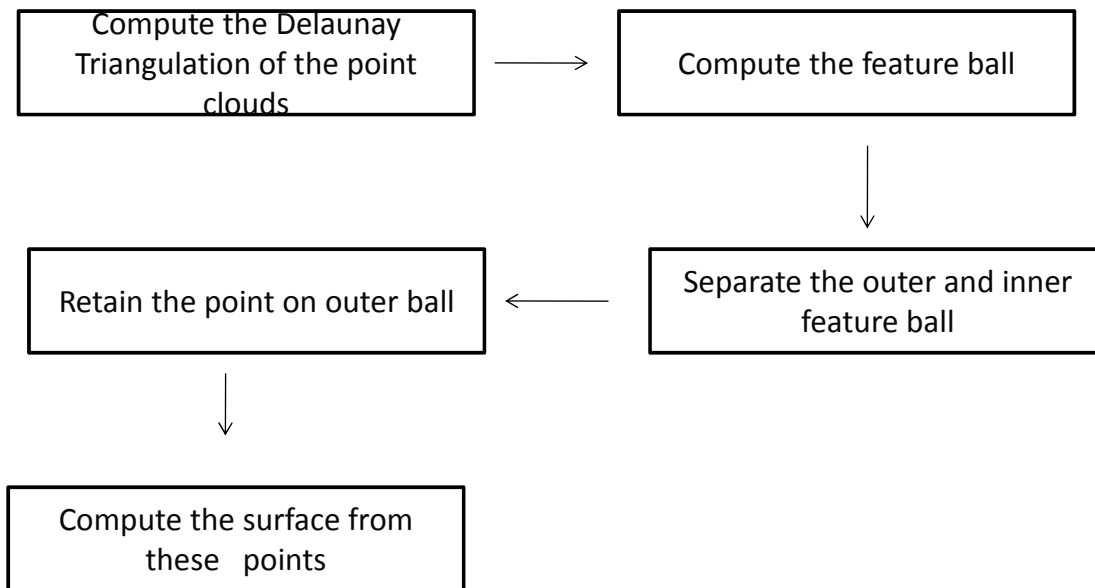
IMPLEMENTATION

Laser scanner

Object

(a)Bowl

(b) Vase

(c) Skull

Commercial and open source software
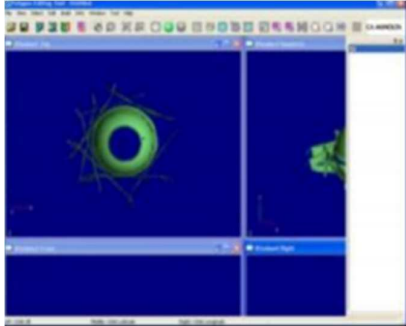
Polygon editing tool
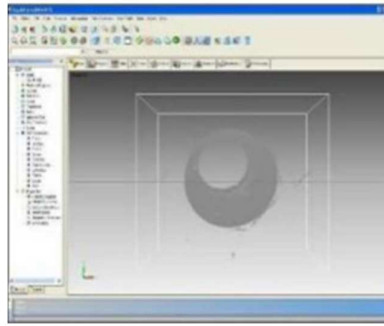
RapidForm
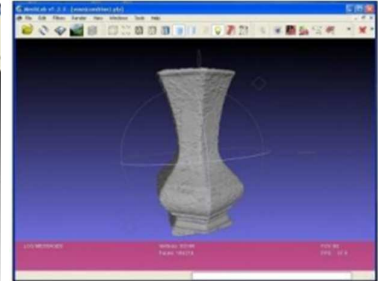
MeshLab

Matlab
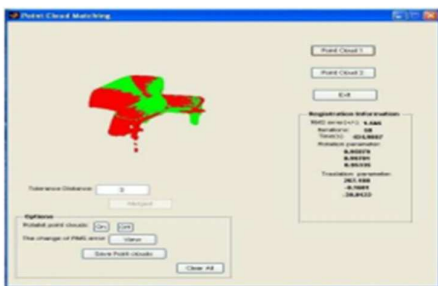
Point clouds registration
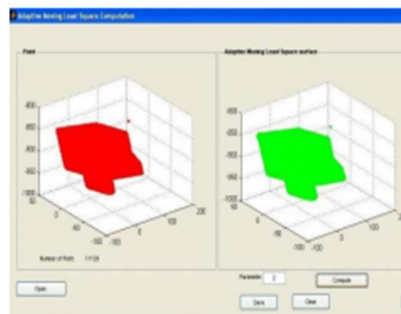
The computation of AMLS surface

Surface reconstruction

RESULT AND ANALYSIS
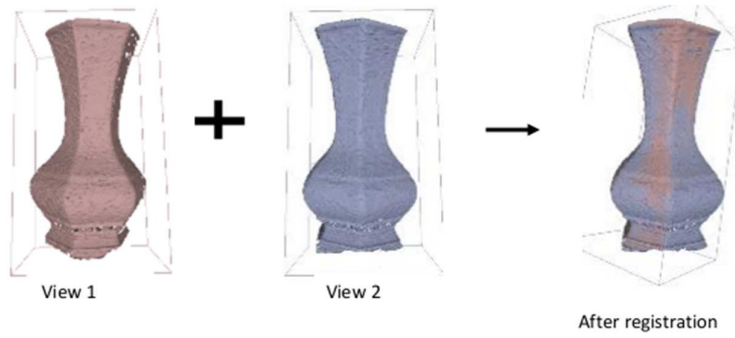
Before and After registration
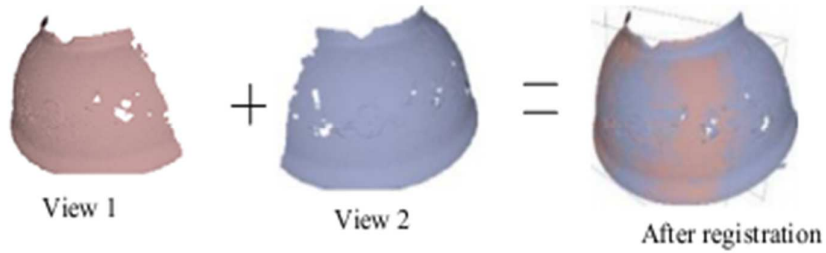
Bowl model

Vase model
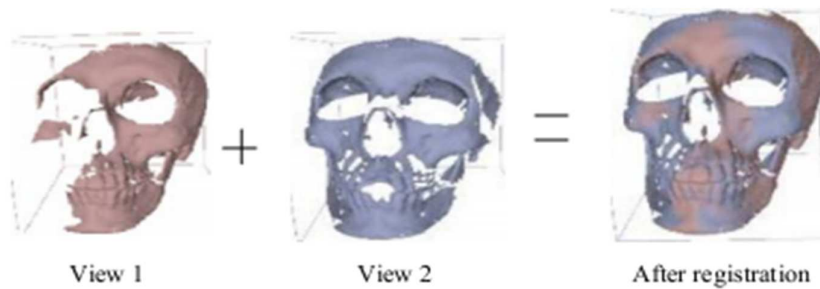
Skull model

Comparison of iteration and RMS error for ICP algorithm

Model	RMS error from classical ICP algorithm(mm)	Iteration of classical ICP algorithm	RMS error for proposed ICP algorithm(mm)	Iteration of Proposed ICP algorithm
Bowl	3.7133	25	3.714	14
Vase	0.2987	32	0.302	25
Skull	0.5333	27	0.529	14
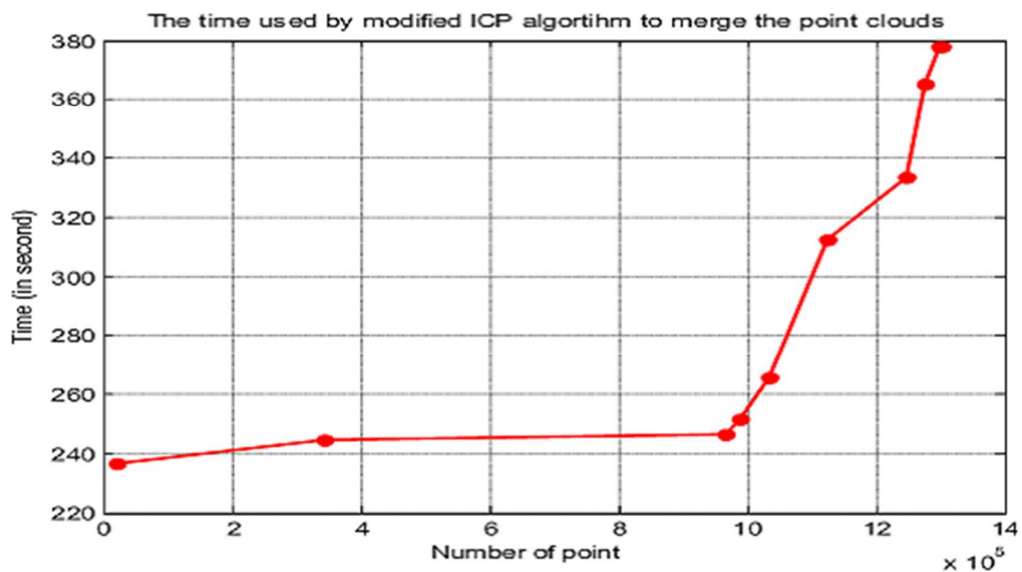
The graph shows the time used by modified ICP algorithm to merge the point clouds when the number of sample point increase.

3D SURFACE FROM HYBRID TECHNIQUE VS 3D SURFACE FROM RAPIDFORM

Bowl model

Surface from RapidForm

Surface from Hybrid technique
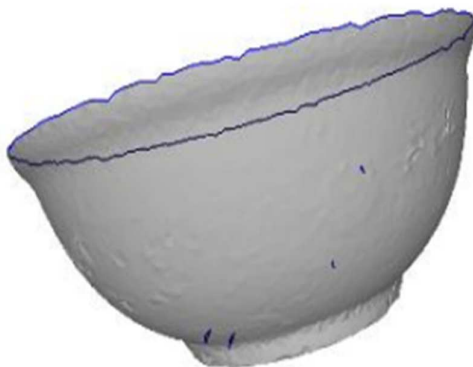
Hole on the surface is marked by the colour blue

Vase model

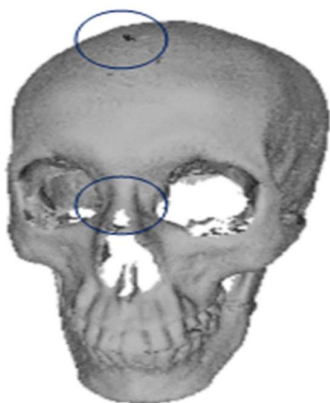**Surface from RapidForm**   **Surface from Hybrid technique**
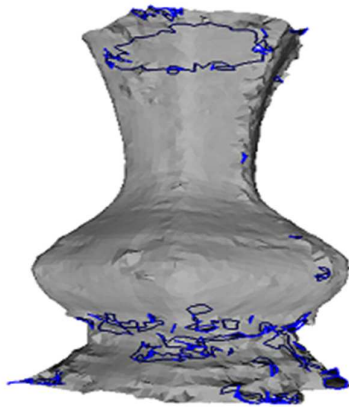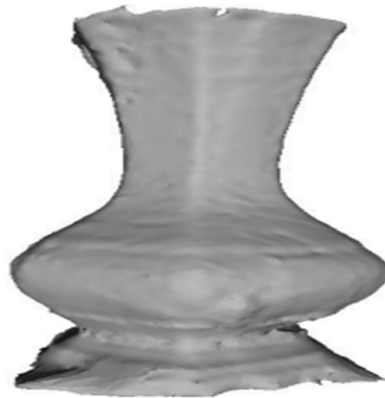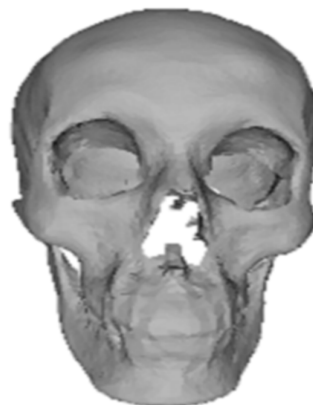
Hole on the surface is marked by a
blue circle

Skull model

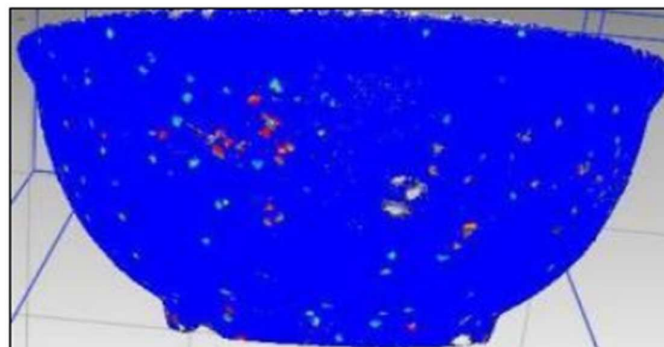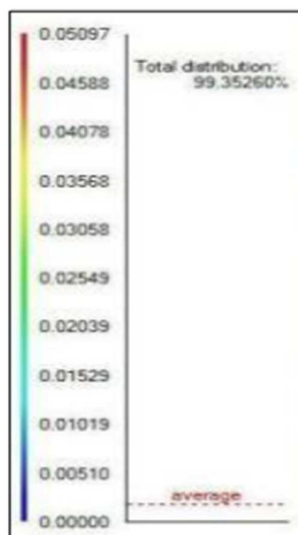**Surface from RapidForm**   **Surface from Hybrid technique**

Hole on the surface is marked by a
blue circle

THE COMPARISON OF FINAL SURFACE GENERATED FROM RAPIDFORM TO FINAL SURFACE GENERATED FROM HYBRID TECHNIQUE
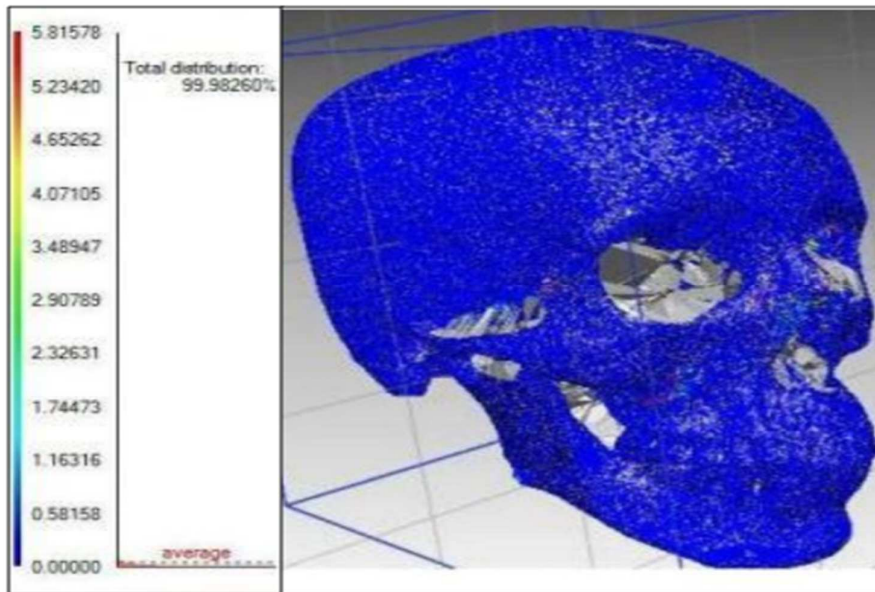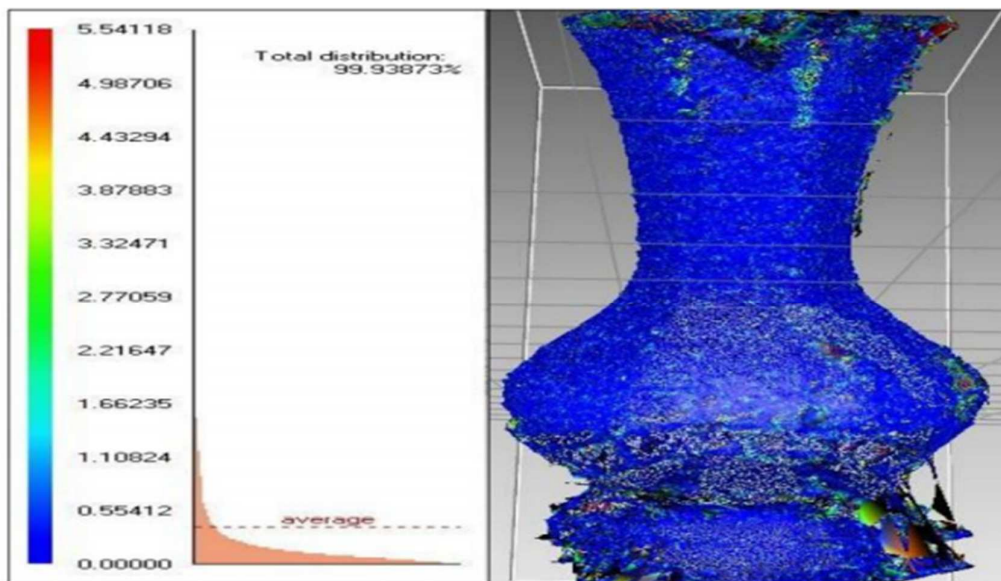

Bowl model (unit in mm)

Skull model(unit in mm)

Vase model(unit in mm)

Box model(unit in mm)
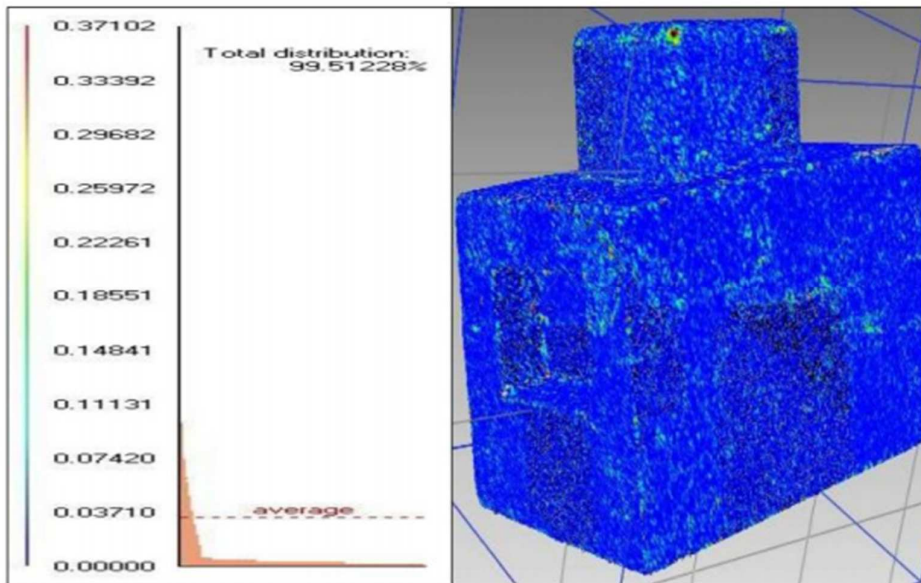
THE COMPARISON OF 3D MODEL FROM HYBRID TECHNIQUE TO REAL OBJECT (MEASUREMENT)
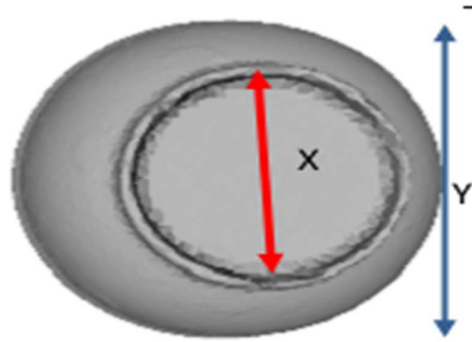
Measurement for real object (cm)	Measurement for 3D model(cm)
X=7.50	X=7.46 (0.04)
Y=15.5	Y=15.6(0.15)

The value in the bracket is the difference between measurements of real object to 3D model
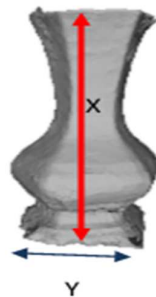
Measurement for real object (cm)	Measurement from 3D model (cm)
X=25.00	X=24.88(0.12)
Y=5.13	Y=5(0.13)

The value in the bracket is the difference between measurements of real object to 3D model
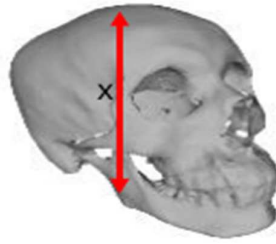
Measurement for real object (cm)	Measurement for 3D model (cm)
X=17.00	X=16.8(0.17)

The value in the bracket is the difference between measurements of real object to 3D model

CONCLUSIONS

Conclusions

Hybrid Technique :

-Always generate a 3D model with a smooth surface (the AMLS surface can reduce the effect of noise in 3D model)

-Always generate the 3D model that free of holes (Delaunay /Voronoi based algorithm that used in this research can automatically remove the unwanted hole on the surface)

-Can become a standard technique to develop the new 3D modelling system

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The weakness of Hybrid technique

- Voronoi Diagram and Delaunay triangulation are the main computational tool in this research

- The computation of Voronoi Diagram /Delaunay Triangulation is costly : $O(n \log n)$

- Imagine : million of point clouds , a lot of time is needed to compute the Voronoi Diagram/Delaunay Triangulation , even provide high performance computer and good algorithm

- The Voronoi /Delaunay based algorithm close all the hole on the surface even the hole that not cause by the noise. The reconstructed surface is not same with the original object.

Future study

- Introduce more practical strategy for point clouds registration
- The generated of 3D model from point clouds without compute Voronoi Diagram or Delaunay Triangulation
- The introduce of new simplication technique in Hybrid technique , so that Hybrid technique can handle huge raw data

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THANK YOU