

Development of Disproportionate Component by using Reverse Engineering and Rapid Prototyping - A Case Study

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ABSTRACT: In product Design & Development process Reverse Engineering [RE] plays a vital role. Reverse Engineering is a technology which provides a good conceptual design when there is a lack of drawing documentation, missing of broken parts of a product. Reverse Engineering is a process that starts with scanning of an existing part or product for obtaining a 3D CAD model. In this paper, the process of obtaining a 3D CAD model of a real world object by Reverse Engineering is detailed. 3D CAD model developed by RE techniques of Point processing, Curve fitting. Further the modifications are made in the 3D CAD model to Improve the comfortably and aesthetic appearance of the product to survive in the competitive environment. Rapid Prototyping [RP] is a technology used for building a physical model from the modified 3D CAD data. Rapid Prototyping produce the physical object layer by layer, which makes the tangible prototypes of the design quickly. This class of technology communicates the ideas clearly with co-workers & customers. This prototype used to check various aspects of profiled dimensions.

KEYWORDS: Reverse engineering, Rapid prototyping, point processing, curve fittings, surface modeling.

I. INTRODUCTION

In an intensively competitive environment product features like shape, size, volume and aesthetic appearance are changing frequently along with customer needs. Reverse engineering (RE) & Rapid prototyping (RP) are technologies used to achieve the above criteria in a quick succession. It is difficult to undergo a conceptual understanding on 3D object. When there is a lack of documentation, worn out of parts, missing a part of the 3D object. Reverse engineering is a systematic evaluation of a product with the purpose of replication

The applications of RE in the industrial area is defined in respect of following aspects:

- Design of a new component. The design of new part comes from an existing real part model.
- Reproduction of an existing component some parts exist for which no design/manufacturing documentation exists but its copy can be obtained by RE approach.
- Recovery of a damaged or broken component. If the surface of a part to be measured is damaged or worn away, the reconstructed CAD model may not be precise compared with the true surface of the part.
- Development of model precision. The engineer can finish a product concept design based on the requirements of function and aesthetics and then use some soft materials, such as wood or plaster, etc., to fabricate models.

Whatever technique is applied, there are several practical problems with acquiring useable, the major ones being

- Calibration
- Accuracy
- Accessibility

- Occlusion
- Fixturing
- Multiple views
- Noise and incomplete data
- Statistical distributions of parts
- Surface finish.

Reverse engineering is widely used in surgical prosthetics, industrial design, manufacturing and jewelry design. Inspection of fabricated part to its CAD model.

In this study, disproportionate 3D object are depicted for physical to digital process. An optical mouse and clutch lever are depicted for 3D object which are disproportionate and does not have any drawings or documents. In addition broken clutch lever part is developed using Reverse engineering and rapid prototyping which crunches the product development time to market the new product.

II. METHODOLOGY

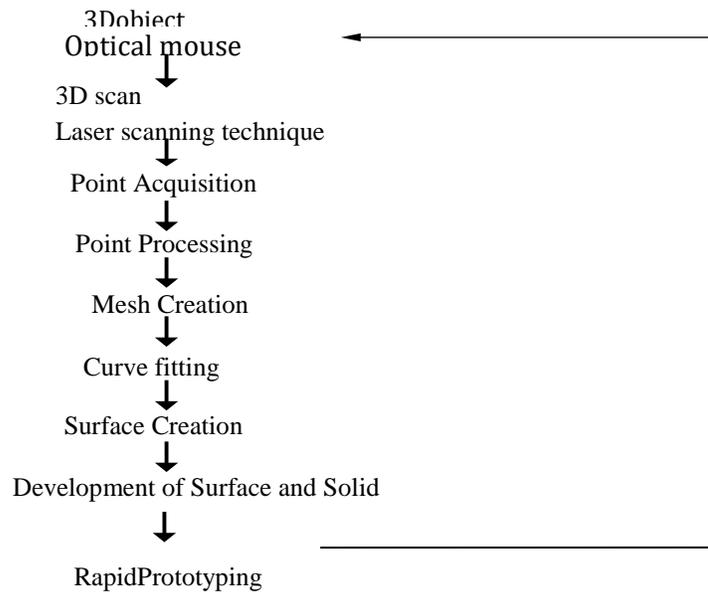


Fig. 1 Step by step procedure of developing a 3D object

III. CASE STUDY 1: Modelling of optical mouse

3.1.1 Data collection: In data collection, calibration allows transformation a 3D real world object to 3D point cloud as show in fig .1

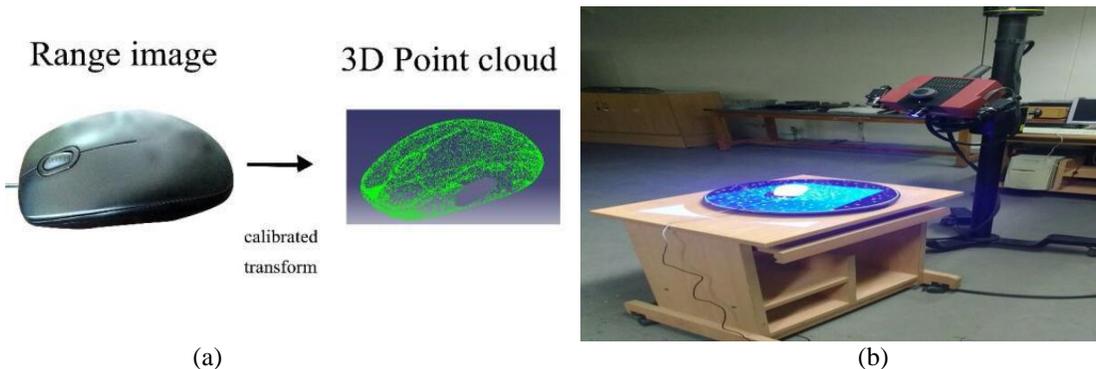


Fig. 2 (a)cloud points of optical mouse,(b)scanning of optical mouse

In fig 2 object shown on the right is the 3D point cloud of the optical mouse. After calibration, view registration is the important step to overcome occlusions. Occlusions are common problems that lead to missing data. While using optical scanning device. In order to overcome this problem the object is placed in rotating table as shown in fig 3 in order obtain different viewing angles. As a result view 'A' (Left side view) and view 'B' (Right side view) is obtained as shown in fig 4. Point clouds of view A and view B is registered to overcome occlusion. Another important problem in scanning optical mouse is the black color of the mouse.

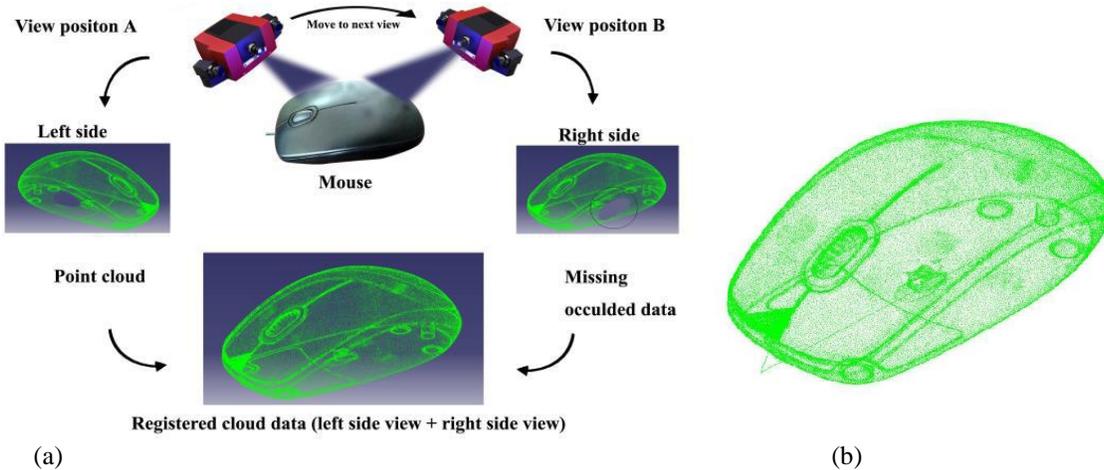


Fig 3 (a) View Registration, (b) Registered Cloud data of optical mouse.

Due to black color of the mouse, the rate reflection of light is minimum, so magnaflux spray is used to increase the rate of reflection. Magnaflux spray will exhibit the following characteristics for better scanning.

- Easy method of application
- Even matt coating
- Fast drying
- Easy to remove

3.1.2 Mesh creation:

Point cloud data will captured at accurate level. Once we have collected various views of an object and registered those views to create a point cloud. Mesh is created on the point cloud is shown in figure 5. Sampling is the number of points in the point cloud and the distance between each points in the point cloud. Some times over sampling and under sampling may happen over sampling leads to over whelm computing resources and under sampling lead to incomplete & inaccurate models. In order to develop accurate model adaptive sampling point should be of required level. Mesh is created on the adaptive sampling point and the number points is tabulated in table 1.

In most cases the NURBS are necessary to create a 3D CAD model from cloud points.

Table. 1 Cloud data's:

Sampling points	128971 (100%)
Adaptive sampling Points	57155 (44.32%)

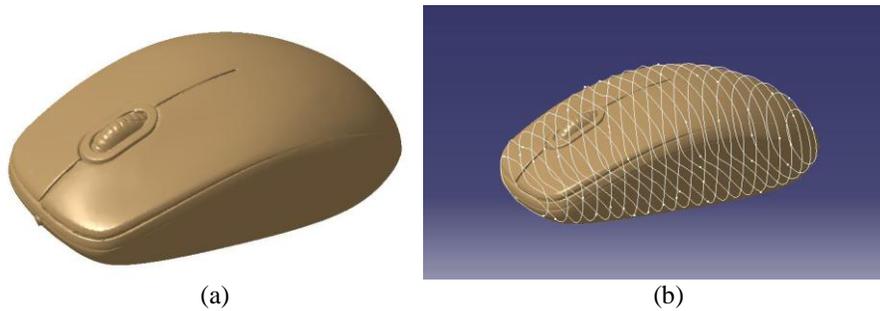


Fig. 5(a) Mesh created on the adaptive points. (b) Curve generation

3.1.3 Curve fitting:

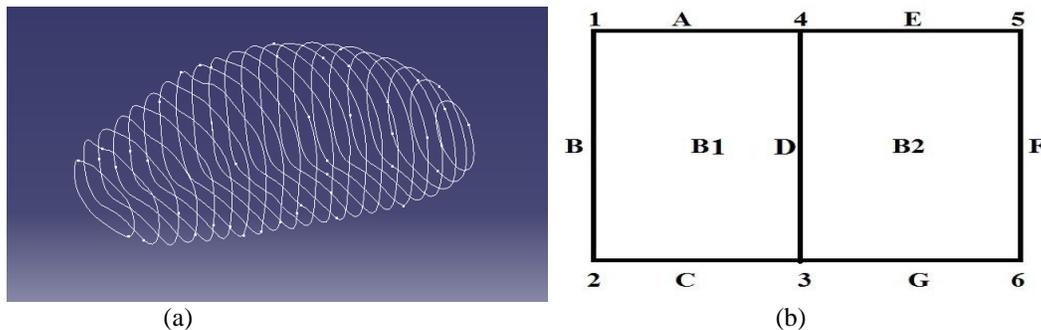


Fig 6 Curve fitting (a) Sectioned curves, (b) Boundary curves for surface patches

Conventional approach to transforming point cloud set to a curve can be classified into two categories triangular polyhedral Mesh method and segment and fit method. The mesh created is optimized to form curve in mesh method and in segmented & fit method, the point clouds are segmented automatically or manually to form boundary patches and each defines surface region of optical mouse Cloud data (segmentation are done by segment & fit method). Manually and each segments are used to fit segments curves or boundary curves to define the surface region of optical mouse. Sampling points, segmental points details are tabulated in the table 1.

3.1.4 Surface fitting:

Design representation of complex objects are created using surface modeling. Surface modeling provides precise and accurate objects. It can be used in engineering and design environment, also for calculating mass properties, generating finite element meshes, checking for interference between mating parts due to richness in information of surface models. Surface models requires some quantitative and qualitative data. Quantitative data's such as shape and smoothness qualitative data structures required to form a surfaces are edges, vertices and blocks are shown in fig.8. The surfaces s1 & s2 are created using the edges ABCD and DEFG and its vertices 1234 and 3456. Thus the multi section coon surface are created in a closed boundary in figure 9. Thus the surfaces are closed to form a solid.

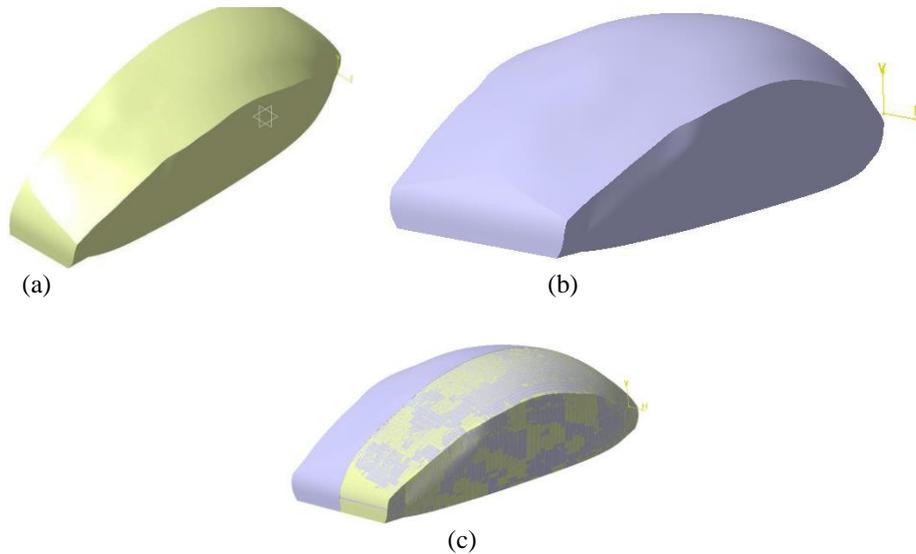
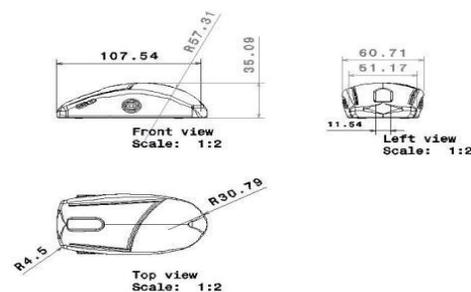
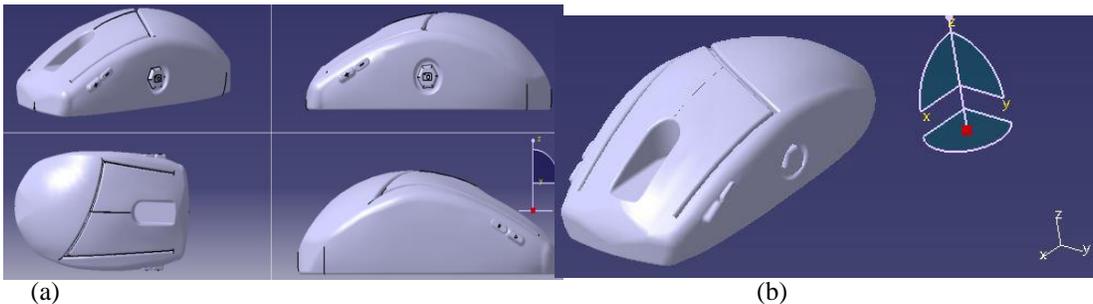


Fig7 model creation (a) symmetric surface model (b) solid model (C) Combination of solid and surface

3.1.5. Solid models

Solid model is the easiest method of the three modeling technique (curves, surfaces, solids). The solids are created from the closed surface. Using the close surface option available in 3D modeling software Solids is created. Thus the created solid are merges with surface. The solid model of optical mouse are used for re- modification to improve the comfort ability of the user and some aesthetic features like slot for sensor scroll, volume button, print screen buttons are added to the optical mouse and dimensional layout is prepared using the modified model.



(c)

Fig 8 (a) modified optical mouse, (b) After modification (c) Dimensions of optical mouse.

3.1.6 RAPID PROTOTYPING

1. Surface model or solid model created in RE process needs to be converted to STL model. The STL model is sliced to generate a layer – based model (RP model). Thus the prototype optical mouse is shown in figure.

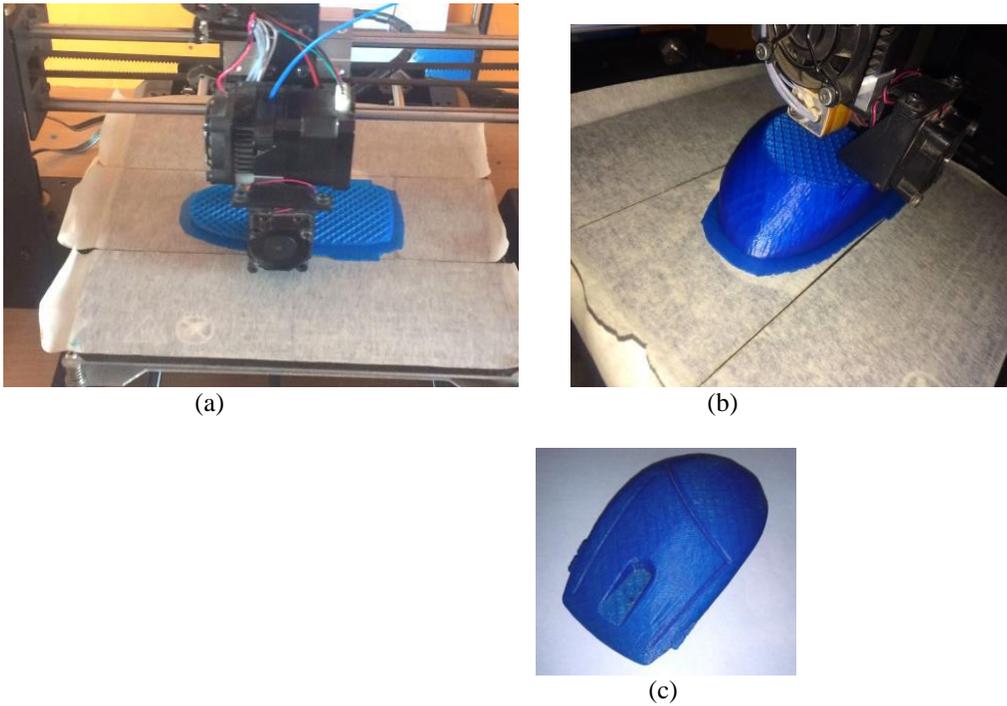


Fig 9 Prototyping using 3D printer (a) layer formation (b) during layer formation (c) finished prototype

IV. CASE STUDY II: MODELLING OF CLUTCH LEVER

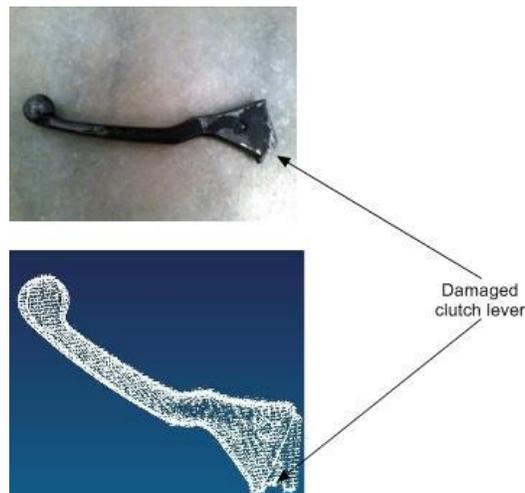


Fig 10 Damaged clutch lever

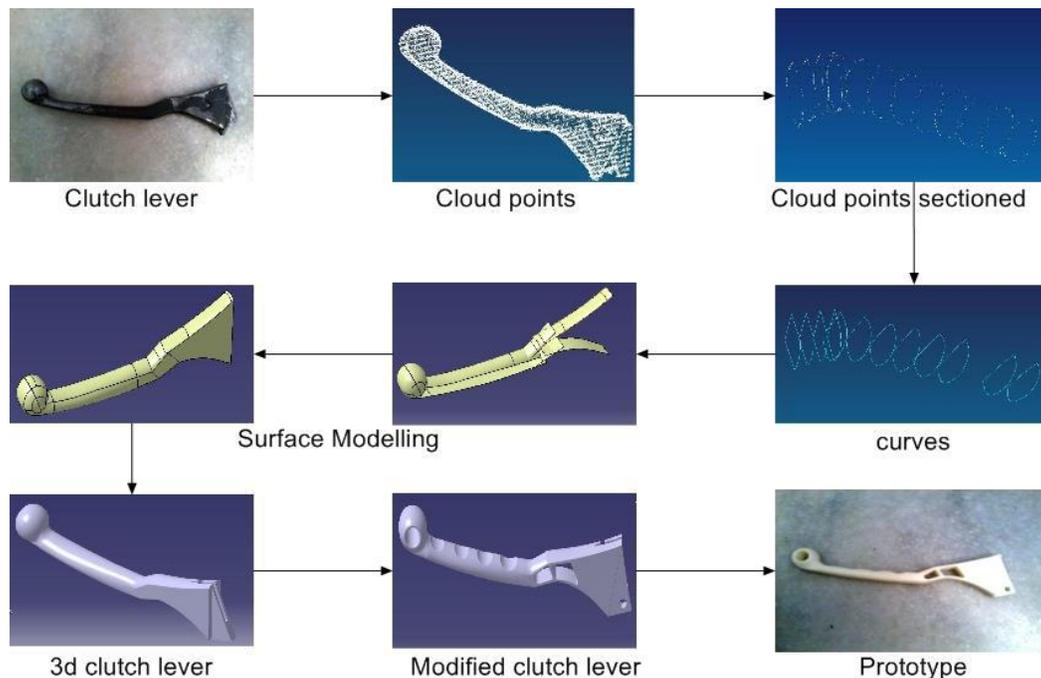


Fig.11. Step by step creation of 3D-CAD model for clutch lever

Clutch lever which is needed to remodeled using 3D modelling software and then prototyped.

This process is seen in Fig. 7. An example showing the steps for the 3D CAD model creation for the clutch lever is as follows:

Step 1. Scanning of damaged clutch lever and cloud points is obtained

Step 2. Determination number of acceptable section to create sectional curves.

Step 3. Further the surface is created in sectional curves and closed surface is formed

Step 4. Closed surface model is converted into solid model and the damaged part is developed.

Step 5. Developed solid model is converted into modified clutch lever which has sporty aesthetic appearance as well as reduction in material

V. CONCLUSION

In this paper, the process of RE in developing a 3D CAD model from point cloud is detailed and the modification of mouse and reconstruction along with improvement in aesthetic appearance of damaged clutch lever. Further the relationship between reverse engineering and rapid prototyping is discussed. The rapid prototyping model is fabricated. In future, the fabricated prototype is measured in CMM and 3 types of shape error will be evaluated to find the deviation.

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