Reverse engineering

Engineering

Businesses can not afford to fall behind as consumer emends are constantly changing. Reverse engineering allows companies to have an edge, as their flexibility through adaptation is enabled through reverse engineering. (Raja & Fernando, up 1-5, 2011) Reverse engineering has been split up into 3 sections which consist of: Scanning Point Processing Application of model geometric development (Raja & Fernando, POP-6, 2011) One of the concepts of reverse engineering is to be able to replicate an existing part, when no data of the part is available initially.

Being able to reproduce the geometric data of a part from a model to a computer Is Integral to reverse engineering. New technologies such as 3-D scanning have helped establish the field of reverse engineering, as It has allowed for geometric data existent within a model to be represented in a digital form. Reverse engineering uses 3-D scanning in a sense that the original model is our data source; through scanning this design, data is obtained on the computer so as to enable changes to be made. The scanning methods use Computer Numerical Control (CNN) system, which control the probes and the gathers the data. Wage Wang, 2010) 3-D Scanning methods: There are two main classifications of 3-D scanners existent within industry, one being intact scanners and the other being Non-contact scanner. Contact scanners work on the principle of using contact probes to brush along the surface of a model, and differentiate each form on the surface of a part from another. These scanning methods have proven to be extremely accurate, often having accuracy to the nearest 0. 01 mm. These scans enable accurate representation of physical data to be obtained in a digital form.

As a probe brushes across a models surface it exerts a force so as to allow the touch probe to sense the surface of a material. However, there Is a major disadvantage to this as correct scans are not be ajar shortcoming of using the contact method for scanning is that it is extremely slow. Gathering features on the internal part of models can be difficult to obtain, through this method, as the touch probes are unable to reach these areas. (Wage Wang, 2010) There are 2 types of technologies existent in manufacturing the Point-by-point Measuring method, which uses touch trigger probes to scan the model.

A Coordinate Measurement Machine (CAM) is used so as to obtain coordinate points on the surface of a model, this allows for a 3-D scan to be created, through the use of different data points on the surface. The second method known as Analogue Sensing uses scanning probes, usually with the help of a Computer Numerical Control (CNN). The CNN detects analogue signals from the scanning probes, through the movement of the probes across the surface of the model. This method can also use CAM, however a CNN is the preferred device, compared to Point by point measuring this method is 2-3 times faster.

This machine is extremely accurate to the degree of B±O. II mm. Contact methods have several advantages such as high accuracy, low cost of hardware and software; and it can easily differentiate colors from one another. Furthermore the ability to measure deep slots within a model, is beneficial for complex parts. The slow speed of the scanning process, and disruptions occurring due to materials deforming on contact with the probe are disadvantages to this process. As these materials are too soft, they are

hindrances to this process. Raja & Fernando, up 34-39, 2011) The other main 3-D scanning methods is Non-contact scanning technique this uses lasers, optics, and charge coupled devices (CDC). This technique is quicker than contact scanning, as large amount of data is captured quickly. In some cases multiple cans may be required so as to represent all the data from the model, this is a major drawback for this process. The scans are produced through capturing the reflected rays and reconstructing an image. In some cases where the surface of a model is inappropriate for this type of scanning.

For scanning to take place the surface of models need to be covered with a different material so as to allow light to be easily captured by the scanner. (Reverse Engineering of geometric models Vary; Martin; coot, 1997) Non-contact methods of capturing data from a 3-D model, requires the use of a form f light energy. As mentioned earlier this method allows for models to be constructed quickly, as well as capture images of models made from softer materials, as there is no contact between the testing method and the model.

Non-contact methods of scanning work on the principle of capturing many 2-D cross-sectional images, data from these images known a point cloud data is used to reconstruct an image. Disadvantages of this process include the restrictions of detecting certain colors, as well as the accuracy of the reconstructed models. As 3-D scanners can be accurate to ±O. Mm to 0. 2 mm, which is not as accurate as the contact method of scanning. Several advantages are existent in using Non contact methods of scanning the first does not deform products with softer surfaces.

There are several techniques used to obtain 3-D images of a model using non-contact methods these include the following the type of scanning methods, these are the most used in engineering to replicate the geometry of a model: Laser Scanners or Triangulations- this works on the principle of light being pointed at the surface of a model, the deflected light is minted towards photosensitive CDC camera which calculates the coordinates of a particular point on the image.

Using the appropriate filters an image can be generated, however certain complex shapes may not allow light to be reflected in certain planes. Thus another scan will be required to obtain the full image. Interferometer uses structured light patterns to allow for deformations to be measured, this is known as the Moire effect. Light contours are captured in an image, analysis of the distance in between lines is used to help create a 3-D image. The mime of flight method works on the principle of measuring the time for the light to reach from source to the light reader.

This allows for a 3-D image to be constructed based on the measurement of how quickly or slowly light returns to its receiver. Allowing for coordinates of the model to be generated at each point, based on the time taken for light to return. Lasers used in this method are sent in pulses so as to allow to the measurements of time to be taken. Non-optical techniques using sonar and microwave rays have also be used to construct 3-D scans, this however has to had many implications in manufacturing. Main uses are detection systems used in submarines and airplanes. Raja & Fernando, 34-39, 2011) (wage Wang, 2011) Processing of data The second landmark existent in current reverse engineering techniques includes that of " Point Processing". This is

the process of obtaining data through the scanners, and the filtering the data. As the scanned data has many points (known as point clouds) which have been used to create a 3-D image of the model. However to construct a model using such a high number of points would be difficult, thus the SE of program filters is used.

These are made using complex algorithms which are predefined for each scanning process, these algorithms are used so as to recreate the surface of the model. In recent time this has been considered to be one of the hardest tasks in reverse engineering, as only accurate algorithms will allow for a correct model to be constructed within CAD. As not all aspects off model can be observed in one scan, point processing allows data from several scans to be used to construct a digital model. Point cloud data allows for 2-D cross sectional images to be add into 3-D model, once the correct algorithmic filters and software are present. Reverse Engineering of geometric models, Vary; Martin and Coot, 1997) The final stage in successfully completing the reverse engineering process is to find suitable applications for the process. Several industries such as the automotive, aerospace and other manufacturing industries, use reverse engineering to enhance their businesses. If changes have been made too part physically, to save time in reconstructing changes in CAD, reverse engineering techniques are used to allow for analysis on a computer to take place. Wage Wang, 2010) 3-D scanners have allowed companies to bring products to market faster, as well as save engineers time in having to recreate CAD models. The two methods of Scanning aid reverse engineering immensely, with contact methods being more accurate and slow. Non-contact methods are more popular than

contact methods of scanning, as they are faster and can scan large models quickly, with further development their accuracy will improve. Reverse engineering. Problem: Toyota in last few years have become the largest car manufacturing company in the roll.

In 2005 their manufacturing plant in North America faced difficulties in being able to produce the Toyota Oval for the American market. This problem was not related to the design of the product, but with the equipment that would be used to manufacture this product. The rocker panel of this model was closer to the ground than any existing model of the Oval. A problem in manufacturing arose due to this, as equipment would need to be changed or modified to allow the automobile to be manufactured successfully.

When new models are to be created on a line, manufacturing equipment often needs to be changed this incurs large costs for the business. Especially in cases where new machinery needs to be purchased to manufacture a new model, these costs can be very large capital investments. Sometimes companies analyses their own equipment and make these changes in house, however this did not occur very often at this particular Toyota plant. Usually new machinery would be purchased or old machinery would be sent to a specialist contractor, who in turn would modify manufacturing equipment to suit a manufacturing process.

The process of hiring a contractor to modify equipment, as ell as purchasing new equipment for a given process, incurred high capital expenditures. Thus in 2005 the production manager of this particular Toyota plant, turned toward reverse engineering so as to enable the company to save money

during this process, by being able to modify their own production equipment. Testing of different techniques: Toyota tried several reverse engineering technologies using 3-D scanning, so as to help model the geometry of manufacturing equipment accurately.

Before correct and complete scans could be generated, 3-D scanners currently being used could not future all the geometry for the larger pieces of equipment. This required experimentation with different types of 3-D scanners to take place. Finally non- contact method using laser scanners was successful in obtaining full geometry of equipment that was mm x mm x mm in size. Using outside experts allowed Toyota to run trials using several different models of different 3-D scanners, in the end laser scanner worked best in capturing the geometry of the equipment.

The experimental part of this process was conducted with members of the Toyota production team working with outside experts, from a company called Can-Tech, ethos. Laser scanners come in three different types; Triangulation, Time of flight, and Phase shift scanners. The Time of Flight type of laser scanner was found to be the most suitable for measuring geometry of large models, that were existent within the plant. Final Implementation: The Z¶leer and FRR¶Welch company develop 3-D laser scanners, Z + F Images 5003 was chosen as the appropriate scanner to be used in Toyota.

Laser scanners using the Time of flight, work on the principle of laser beams being emitted in pulses from a source onto the model. On hitting the surface of the manufacturing equipment the easer beam is made to reflect back

towards the scanner. The time taken for the laser beam to reflect of the manufacturing equipment is measured. Using the speed of light and the time taken for the laser beam to return to the light sensors, coordinates for the surface of the model can be assigned.

Having successfully generated the models engineers working in Toyota were able to modify equipment designs easily for changing car models. This technology allows Toyota to view CAD models of equipment, which allowed them to identify what pieces of equipment need to be replaced or modified for the new Oval design. Results: This technology allowed Toyota of create CAD models for 250 machines across their facilities in North America, as equipment could be easily modified when car designs changed.

This in turn has saved Toyota million of dollars in investments on plant equipment, as older equipment could easily be re-purposed to perform tasks for newer car designs. The whole process saved the company in having to invest in new equipment. Thus Toyota bought this particular model of 3-D scanners, so as to allow for changes to their present equipment to be made. Toyota benefited from this genealogy, as they did not have to purchase new equipment for all of their models, or pay other companies to re-purpose their existing equipment.

Toyota were able gain a significant costing saving, straight of the factory floor, which in turn would allowed them to be more competitive. These savings helped Justify the expense of purchasing 3-D scanners to capture digitized CAD geometry for plant equipment. Modification to take place at a later stage. Once models for the equipment were created. This allowed this

production equipment of this Toyota plant in North America to be more flexible, in regard to their production equipment.