Automated a complex computer aided design concept generated using macros programming

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Abstract. Changing a complex Computer Aided design profile such as car and aircraft surfaces has always been difficult and challenging. The capability of CAD software such as AutoCAD and CATIA show that a simple configuration of a CAD design can be easily modified without hassle, but it is not the case with complex design configuration. Design changes help users to test and explore various configurations of the design concept before the production of a model. The purpose of this study is to look into macros programming as parametric method of the commercial aircraft design. Macros programming is a method where the configurations of the design are done by recording a script of commands, editing the data value and adding a certain new command line to create an element of parametric design. The steps and the procedure to create a macro programming are discussed, besides looking into some difficulties during the process of creation and advantage of its usage. Generally, the advantages of macros programming as a method of parametric design are; allowing flexibility for design exploration, increasing the usability of the design solution, allowing proper contained by the model while restricting others and real time feedback changes.

1. Introduction
In the past, CAD was referred as Computer Aided Drafting and nowadays, it is commonly referred as Computer Aided Design, where it refers to software that helps designer in a wide variety of industries to design and manufacture various types of products such as cameras, cars and aircraft.
The history of CAD started in the early 1950s with a developer of the first graphical system. It was designed for US Air Force's SAGE (Semi Automatic Ground Environment) air defence system that was developed at Massachusetts Institute of Technology. Generally, the system was used to coordinate radar station and directed airplane to intercept incoming planes [14]. In 1957, the first commercial numerical control program system was developed which called PRONTO and it became the pioneer contribution to computer aided design and manufacture [13]. From 1970s to 2000s, the evaluation of CAD software was vast in development and it has been used in many fields of areas [9]. Nowadays, CAD software is not only used for drawing only but various other areas have utilized the modules from CAD software for the purpose of analysis, manufacturing, and visual-prototyping. Some of the CAD software is considered low end and easy to use, other offer as a higher order modelling and
designing that are costly but more efficient and it’s also capable as collaborative design where multiple users can work with the same design at the same time.

Generally parametric modelling is a capability to edit and update graphics components. This is done by controlling certain modelling attributes and behaviour of the object design. The model maintains consistent relationships between elements as it is manipulated. The objectives of this study are; firstly, to understand the concept of parametric design methods, hierarchical constraints and rules. Secondly, to develop a model by understanding the concept of the design and configuration of the programming line as a fundamental of macros programming. Lastly, to generate a complex model of commercial aircraft by implementing parametric design using macros programming.

2. Literature Review
The study of parametric design has been discussed in previous study done by [1] [2] [3]. [4] stated that design procedures are important questions bringing the validity of design with respect to design languages. His studies look into simple analogy, where the variations of parametric model created instances which normally grouped in a category named as a family of design bringing up a greater number of design instances. Another important aspect to consider is the evaluation of the design instances. [12] stated that there are three types of evaluation of the design, which are; performances based, aesthetic and compliance. Performances based, look into a design instances with respect to an ideal result so that model is modified with respect to the ideal one. Aesthetic on the other hand will determine if an instance satisfies a set of value determined by the designer. Lastly, compliances assert if a design instance fulfils a predetermined set of requirements. The paper by [8] presents a surface generation tool designed for the construction of aircraft geometry. The generated of complex geometries is based on Partial Differential Equations where it can generate a number of different configurations of the aircraft shapes interactive in the real time by setting a small set of design variables, instead of hundreds of control points. The shape of the surface is defined through boundary conditions and using a small set of design parameters. From above studies, it shows how important and complex parametric design towards CAD part creation.

In design level, it is important to decide between which levels of detail of the features needed to be presented in a parametric form. Based on the frequently design requirement, the designer will propose varies concept of design for future modification. The study done by [6] explains that the terminologies of parametric modelling are based on; design unit, functions features and form feature. In contrary, dimensions are considered as a constraint that affects a particular set of points in the model and therefore mathematical equations can also be set up within dimensions and features that can have a hierarchical relationship. The other consideration is the design interest should be error free from under-constrained or over-constrained.

3. Methodology
The most important aspect of creating an automated parametric design is to understand the design concept. For example, if creating a cylinder with a centre hole, how do you control the requirement of object dimension changes? Will the requirement of flexibility needed be just outer diameter, inner diameter or both? The standard rule is to create an understanding of design concepts that stated what the requirements needed to be parametric, and what will stay unchanged? This therefore not a problem of an issue for simple design as most of the CAD software is able to reconstruct a design method by simply click a mouse and enter the appropriate new value. The issue of design will arise if there are more requirements needed to be controlled such as the design of the piston head, with parameter requirement, for instance, the size of the object such as piston height, pin diameter, piston thickness, size of compression ring groove and other configuration needed. So, before start creating a design of the part, the understanding of design terminology of the model is considered important because the end parametric model creates will only reflect on the current setting that the user created. As basic rules, the ground of automated design is the generation of geometry from the definition of a family of initial parameters and the design of the formal relations they keep with each other’s. It is about the use
of variables and algorithms to generate a hierarchy of mathematical and geometric relations that allow us to generate a certain design, but to explore the whole range of possible solutions that the variability of the initial parameters may allow.

Generally a CATIA V5, the CATScripts / CATvba structure consists of:

a- The part body
b- Sketch plane
c- Set the axis system of the sketch
d- Sketch geometry and feature

The structure of the programming line is created by a CAD software are based on the software itself. CATIA V5 program structure start with the part body, then sketch plane, define the axis of the sketch and lastly apply add on feature to convert a two dimension sketch into a three dimensional object.

The programmer, need to familiar with the variety of design interest before recording the macros. The general questions that the designer needed are: what do the parametric design information required, understand the flow of the macros programming and how to overcome the problem with error from the program line or command.

3.1. Case study of macros programming (Design of a commercial aircraft)
The purpose of having an automated design of commercial aircraft is to look into the variety of designs of the aircraft under various specifications. In this study the model created is used to run various problem of design. Example: What are the effects of different configurations of the wing design towards the air flow, using CFD software? With this model the analysis can be done with ease because the data or specification that is required is by key-in the required value and the new model will be created.

Figure 1, show the parameter required for a commercial aircraft design that consist of the fuselage, wing and tail section.

![Figure 1. Requirement of commercial aircraft design](image)

After the requirements have been set, the flow chart was created to cater the design of the surface. The design of the fuselage, wing and tail section (vertical and horizontal section) will follow the same flow chart that is shown on figure 2.
Generally the design of the selected surface will start by sketching the requirement of the design according to certain known requirement. The data is recorder and later testing is done. If there is an error, the process will have to start again. If successful, the macros are edit and application toolbar is created. The toolbar is test for the last time, to check for some errors, if no errors, the macros of the design are completed.

It is important to ensure that all feature created will follow the requirement that is set by looking at the structure and its contents. The only best solution if error still occurs on the scripting part is to start and recorder the sketch step as per pervious procedure. Observations of the sketches are the most important consideration. Any value that is created, the sketches have to be written down so that the previous value is notified, later for the purpose of editing the macros.

The macros are edit by adding a message box functions. There are 2 basic internal function added on the macros line such as MsgBox() functions: the format such as written below:

```plaintext
yourMsg=MsgBox(Prompt, Style Value, Title) and
myMessage=InputBox(Prompt, Title, default_text, x-position, y-position)
```

This message box is use to create a pop-up message box and this allow the user to enter the command. Another statement of the macros, such as element value, other function such as formula, and if, else statement. Below is the sample of the line program that is added or edit and the message that will pop up when the program is running.

![Flow chart of decision making for macros programming.](image-url)
In order to look whether the macros works, the macros were tested for it functions. A toolbar icon is created to ease the user using the macros programming. By clicking a toolbar icon, a massage window will pop up. The user has to follow all of the requirement of the design before the surface is generate; any parameter that is not enter will result in error to generate the surface design.

Below is the two variation of the design created using macros programming.

**Figure 3.** Shows the program line a Massage box pop-up.

**Figure 4.** Automated aircraft surface design for Boeing 737-400 and Boeing 777
4. Results and Discussion

The studies compare between two different configurations between Boeing 737-400 and Boeing 777, where both design required 13 parameters with different value. Both have been create successful using the macros. The scale of the design has been set to a ratio of 1:1000, so value are entered in the unit of mm because the measure scale of the software are in a unit of mm instate of meter. These macros can also be used with different configuration of the design that fall under same requirement. The important aspect that should take into account is the parameter that is required for the design. Basically there are some changes of the design requirements from one model to another, where a new parameter need to be added to the macros structure to create a new set of the aircraft configuration. The automated application is using macros programming helps the designer by reducing the time to redesign or alter the complex problem of the design. The reason of macros programming is to create a different group of configuration from the previous design, therefore create a group of similar design with different variation of configuration. This will help what if questions from the design expect of view when tailor the specification of the aircraft. Basically having an automated design helps a user from different area of field to generate the model that is required without the full knowledge of the CAD software because by simple click of the toolbar, entering the requirement of the design, a new design concept is created.

Parametric models have the general purpose of providing a framework for manipulation of geometrical components that perform transformation during the design process. Such advantage discuss by [4] are, be able to perform changes of a geometrical components without erasing a redrawing, increase reusability of the design, allow some transformations, while restricted others and it provide real time feedback when changes in the parametric model to another of the design take place. In reality, the approach has proven to be very useful to capture different variation of the design in the early stage of conceptual design beside reduce time of recreate a new variation of design.

The problem with macros programming is the knowledge of the user towards the creation of the macros. Basic knowledge of programming using visual basic and the structure line of CATIA V5 help a lot toward understands the syntax from the command. Observation and learning will be important so that the structure of the program purely understood; the concept of the design must be gathered so before the sketch of the object is take into account. There is no short cut in programming, because the more complex the requirement of the design, the more difficult the macros need to be edit and created, this is where the requirement to master the CAD software is important.

The most difficult task that the designer has to solve is how to overcome the initial setup such as deciding what variable need to be parameter which can be a time consuming but worthwhile. Perhaps a carefully and accurate analysis of the pre-conditioning of the setup would provide some solution in the early stage.

5. Conclusion

The design of two different configurations of the commercial aircraft has been done successfully. There is no problem to create a different model from the set of requirement as long the design fall under the same group of designers. In the early stage of the macros programming of a model, if can be found that most of the syntax of the program fall under missing or wrong command from the program line and writing out the set of rules where it is impossible.

The surface generation using macros programming has brought many benefits to designer by reducing a time and improve the conceptual design stage. Improper assumptions made at the conceptual design stage may result in difficulties in meeting the requirement of the design and therefore will require the designer to start the process all over again.

References

[1] E Mermoz, J M Linares and A Bernard 2011 Benefits and limitations of parametric design implementation in helicopter gearbox design phase CIRP Annals – Manufacturing Technology 60 199-02
[2] C Ledermann, C Hanske, J Wenzel, P Ermanni and R Kelm 2005 Associative parametric CAE methods in the aircraft pre-design Aerospace science and technology 9 641-51
[3] Daniel M Fudge and David W Zingg 2004 A CAD-Free and a CAD-Based geometry control system for aerodynamic shape optimization AIAA 1-15
[4] Carlos Roberto Barrios Hernandez 2006 Thinking parametric design: Introducing parametric Gaudi Design Studies 27 309-24
[5] A Veroust, F Schonek and D Roller 1992 Rule oriented method for parameterized computer-aided designs Computer Aided Design 531-40
[6] Guk-Heon Choi, Duhwan Mun and Soonhung Han 2002 Exchange of CAD part models based on the macro-parametric approach International Journal of CAD/CAM 2
[7] Michael Athanasopoulos, Hassan Ugail and Gabriela Gonzales Castor 2009 Parametric design of aircraft geometry using partial differential equations Advances in Engineering Software 40 479-86
[8] Narayan K Lalit 2008 Computer Aided Design and Manufacturing New Delhi: Prentice Hall of India
[9] Andrews P T J, Shahin T M M and Sivaloganathan S 1999 Design reuse in CAD environment Computer & Industrial Engineering 37 105-09
[10] A Veroust, F Schonek and D Roller 1992 Rule oriented methods for parametrized computer-aided designs Computer Aided Design 24 (10) 531-40
[11] Stiny G and Gips J 1978 Algorithmic aesthetics: computer models for criticism and design in the arts 220 p
[12] Ibrahim Zeid 2005 Mastering CAD/CAM Mc Graw Hill
[13] C Bill 1998 Development and application of a computer-based system for conceptual aircraft design Delft University Press