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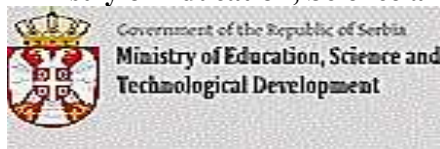
FREECAD IMPORTAIRFOIL MACRO - DRAWING AIRFOIL GEOMETRY IN AN OPEN-SOURCE CAD PROGRAM

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Abstract. *Macro programs used in computer modeling programs have become extremely important due to the high complexity of the models as well as the opportunity to create or adapt a specific geometry as soon as possible. Due to the implementation of the Python programming language, the FreeCAD program is highly suitable for creating advanced macros. When modeling aircraft parts (wings and tail surfaces), wind turbine blades, and similar structures, the biggest problem, due to the shape of the outer contour, is drawing the cross-section of the structures. The ImportAirfoil program allows to quickly and easily import and draw the contour of the desired airfoil, as well as modify it. This paper shows the complete procedure for importing and drawing of NACA2410 airfoil.*

Keywords: *Airfoils, Computer Modeling, FreeCAD, Macro program, Python*

1. INTRODUCTION

FreeCAD is an open-source parametric 3D CAD software. The program has great abilities and subprograms, provides a graphical framework design, and can be easily extended with Python scripts [1]. During modeling, some processes need to be repeated frequently, such as entering points that define the shape of an airfoil. Using the macro program (*Macro*) can automate this process and speed it up significantly. FreeCAD software package uses the Python programming language for macro programs. Also, the C++ programming language is used for the core of the program. The official manual and instructions for the Python programming language are completely free and available for programmers [2].

2. MACRO PROGRAMS

The use of the Python programming language is of great importance, as this open-source programming language is currently one of the most widely used and supported programming languages. It has a large community of users and developers, which makes its development very active and it will certainly be relevant in the future. It is designed to learn easily and quickly, which is a consequence of easy-to-understand syntax. When programming, it is necessary to know the *Object* implemented within FreeCAD. The official documentation for API (Application Programming Interface) lists all objects as well as their *Properties* and *Methods* [3]. Tools for macro programs are located in the Macro drop-down menu and in the toolbar of the same name. In addition to the tools for running and modifying macro programs, there are also tools available for debugging macro programs.

Macro recording is the first tool that is always extremely useful because it is possible to record certain actions and get an automatically generated macro. In this way, it is possible to get methods that are used over objects or to some property of an object without insight into the infrastructure of objects within the program. An example where recording is extremely useful is when creating a catalog of a product that can have many geometric parameters. In this case, it is necessary to record the process of making a model of that product in only one case (for only one geometric parameter). It is then easy to find and modify the values of the geometric parameters in obtained macro to get a whole range of models.

The second method of creating a macro program would be editing and expanding previously written programs. Within the FreeCAD software package, there is also a manager for macro programs and additional workspaces (shown in Fig.1). Additional macro programs and workspaces (written by community members and not included in the software package) can be manually installed directly in the program. It is always helpful to read the code of already written programs because in this way it is possible to learn many ways to implement certain procedures.
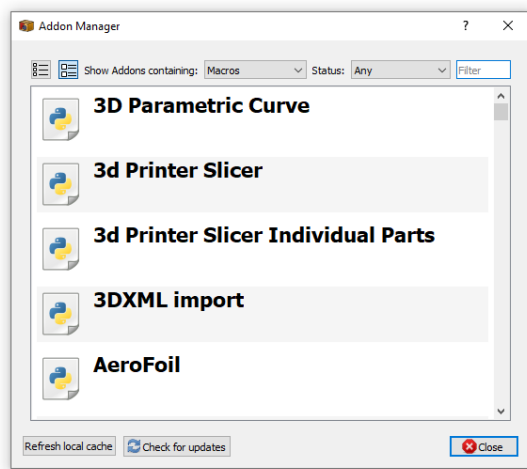

Fig. 1 – The FreeCAD manager for macro programs

The method of recording macro programs is very fast and, in many cases, sufficient, but sometimes it is necessary to do something that cannot be recorded from the graphical user interface of the program. The third and most general method that can be used in programming is writing a macro program based on the official documentation for the API of this software package. Additional documents can be accessed directly in the software package from the *Help* dropdown menu. Within the documentation, it is possible to find every object property and method for objects implemented within the program. It is easiest to reach a particular object by searching within a document. When all the properties and all methods are known, they need to be implemented within the macro program using the syntax of the Python programming language.

3. THE IMPORTAIRFOIL PROGRAM

The *ImportAirfoil* program is a FreeCAD Macro for Airfoil coordinates import. Using simple dialog it is possible to transform geometry (rotate, translate in the plane and along the span and scale), select the drawing plane and the main axis, and also transform

geometry into a sketch. It is also possible to import coordinates saved in the most commonly used formats [4]. The source code for this macro is available on GitHub. This procedure enables the correct shape of the airfoil to be formed quickly and accurately, after which it is possible to create cross-sections of the desired structure (aircraft wings and tail surfaces, wind turbine blades, etc.). When the sections are correctly geometrically formed, it is possible to create the correct aerodynamic shape of the structure. This is especially important in the phase of the conceptual design of the aircraft because it is possible to determine whether the obtained shape is appropriate from the aspect of aerodynamic parameters (lift and drag coefficients).

```
NACA 2410
1.00000      0.00105
0.95041      0.00990
0.90067      0.01816
0.80097      0.03296
0.70102      0.04551
0.60085      0.05580
0.50049      0.06356
0.40000      0.06837
0.29875      0.06875
0.24814      0.06668
0.19761      0.06276
0.14722      0.05665
0.09710      0.04766
0.07217      0.04169
```

Fig. 2 – Part (first 15 lines) of .dat file for NACA 2410 airfoil

To create the airfoil geometry, it is needed to find a file with the points that define the desired airfoil (.dat file). This type of file contains the coordinates of the airfoil points as shown in Fig. 2. Professor *Michael S. Selig* (*UIUC Applied Aerodynamics Group, Department of Aerospace Engineering, University of Illinois*) formed a group that creates and maintains a database with the coordinates of the airfoils [5]. The database is completely free and can be easily accessed. In this research, the procedure of importing and drawing the NACA 2410 airfoil will be shown. He also leads research about propeller performances for small unmanned aerial vehicles [6].

After the opening of the FreeCAD program, the airfoil can be drawn in an existing part or in a new one if it is opened, otherwise, a new part is automatically created. The created macro program, ImportAirfoil, needs to be executed within opened FreeCAD program (shown in Fig. 3).
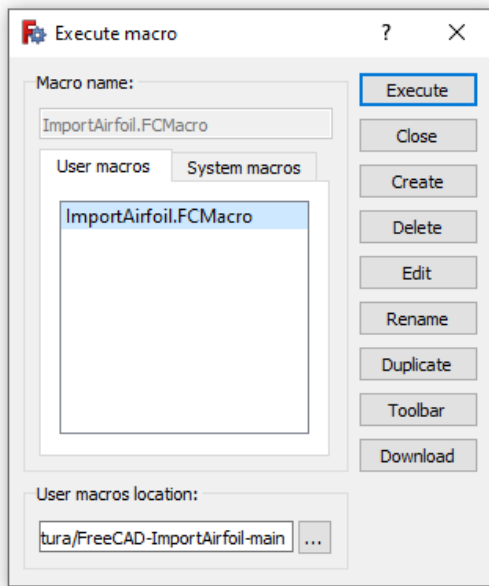
Fig. 3 – Execution of the macro program

At the beginning of the program, it opens a window in which the user is informed that in the next window it is necessary to select a properly formatted file with the coordinates of the points that define the airfoil (shown in Fig. 4).
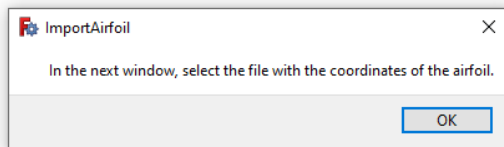

Fig. 4 – First message from the macro

After selecting the document with the coordinates of the airfoil, the user is enabled to scale, orient, and position the airfoil as needed. The user enters all the data in the next, and also the last, window of this macro program, which is shown in Fig. 5. These windows are an example that a macro program can have graphical windows for data input and there is no need to change parameters in the code of the macro each time.

The user enters the following data: the length of the airfoil chord in millimeters, the angle of rotation (twist) in degrees, the relative position of the axis of rotation (twisting) along the chord in percentage, selecting a plane through the appropriate selector (for XY plane enter 1, for YZ plane enter 2 and for ZX plane enter 3), vertical mirroring (enabled if 1 is entered, if 0 is entered no mirroring is performed), change of a horizontal axis with a vertical axis and

vice versa (enabled if 1 is entered if 0 is entered, there is no change of axes), translation of profile along the horizontal axis in millimeters (an axis that is horizontal in the sketch), translation of profile along the vertical axis in millimeters (an axis that is vertical in the sketch), translation of profile along the span in millimeters and creating a Sketch object (enabled if 1 is entered, if 0 is entered only space spline is made, type BSpline).
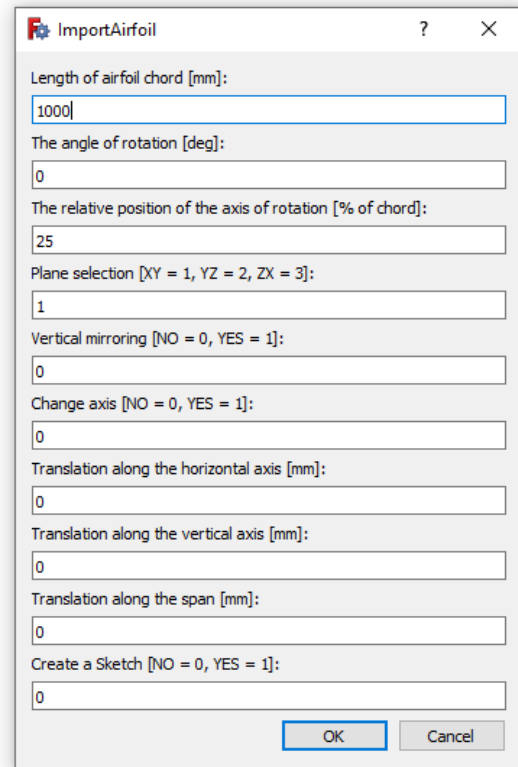

Fig. 5 – Airfoil importing parameters

If there is no error, the airfoil will be displayed in the window (shown in Fig. 5).

Fig. 6 – Imported airfoil

Formed airfoil geometry is an open spline (type BSpline). Each airfoil is processed by opening the profile at the point of the trailing edge and then closing the profile at that place with a straight line (TEdge). This modification aims to obtain a unique upper and lower wing surface. This way only one surface is closed at the point of the trailing edge with

the other surface (otherwise the surface can be split at the point of the leading edge, which is not suitable for further finite element analysis). The final sketch is shown in Fig. 6.
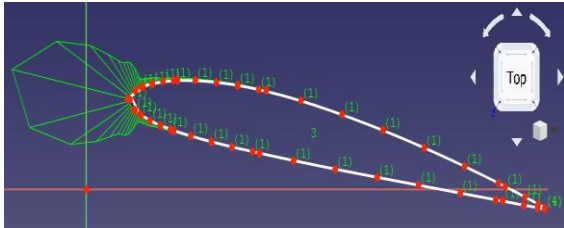

Fig. 7 – The final sketch of the airfoil

4. CONCLUSION

This paper shows the procedure for creating macros for the FreeCAD program, as well as the development of macro for importing geometric airfoil data with custom windows for data input. This macro program allows to quickly and easily create the airfoil geometry in FreeCAD that can be further edited. The macro program offers several simple options for airfoil transformation, which is very important in the process of conceptually designing aircraft wings, wind turbine blades, and similar structures. The source code is published on the GitHub repository.

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