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OBJECT-ORIENTED GRAPHICAL INTERFACE FOR COMPUTATIONAL TOOL OF TWO-DIMENSIONAL ELASTIC-LINEAR ANALYSIS OF BARS WITH STRAIGHT AND CURVED AXIS

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Abstract. This paper describes the details of a graphical interface for a linear-elastic analysis program based on the finite element method with two-dimensional straight and curved bars elements, without considering the shear deformations (Navier beams theory). The software adds curved-axis elements, such as circular arcs, to the linear analysis of bars based structures (beams, frames) as a way to assist the teaching and learning in the structural environment. The interface was developed in Java, object-oriented paradigm and associated with the program already developed in FORTRAN. The system generates the preprocessing of the analysis. Preprocessing includes data entry with constitutive and geometric properties, graphical arrangement of nodes and elements, boundary conditions and loads. This graphical interface is part of a research project aiming to develop a software for analysis of frames with both straight and curved bars, as well as bars with variable inertia.

Keywords: Graphical interface, Object-oriented paradigm, Circular arcs.

1 Introduction

Structural analysis is the most important step in the design of a project (Kimura [1]). In this stage, the criteria for choosing a model that most closely represents the object to be designed is established, and adequately provides the responses of the model when submitted to the considered actions. Currently, the computational simulation of the structure's behavior and its complex systems is essential, in the academic and professional spheres. These systems may be composed of several basic elements, such as straight bars and curves.

The study of arcs has been around in society since antiquity. As stated by Torroja [2], the arc was the greatest tensional invention of classical art. Present in secular constructions, its study and interpretation presents itself with extreme relevance to characterize its behavior. The development of a tool that encompasses this element in its analysis and processing is of great utility and importance.

In Brazil, popular two-dimensional and three-dimensional analysis programs, such as LESM and FTOOL, developed and idealized by Doctor Luiz Fernando Martha of the Department of Civil Engineering of the Pontifical Catholic University of Rio de Janeiro (PUC-Rio) and the ACADFRAME developed in the Department of Structures of the School of Engineering of São Carlos, authored by Doctors Humberto Breves Coda and Rodrigo Ribeiro Paccola, are commonly used. The base elements are just straight bars and these tools are extremely important for their simplicity of input, interpretation of data, easy access and gratuity. However, the lack of other base elements, besides from straight bars, appears as a limitation when it is desired to analyze models of circular arcs, and other curved axis bars.

Therefore, the purpose of this paper is to present the development of a graphical interface that allows the launch and analysis of structures that contains straight bars and/or circular arcs. This work is part of a group of research projects that aims to develop a software for analysis of frames, PAE (in portuguese "Programa de Análise Estrutural") designed to enrich and facilitate the learning and interpretation of structures.

2 Methodology

According to Horstmann and Cornell [3], when a language is totally object-oriented, its main differential is simplicity. Within the object-oriented approach, a good amount of languages are available to enable this development, such as Object Pascal, C ++, Ada, Ruby, Python and Java.

The Java language was chosen for the implementation, since it presents a solid object-oriented base and offers a complete set of components for Graphical User Interface (GUIs). Java officially supports some types of graphic libraries, such as AWT and Swing. For graphical drawings, the JFreeChart library was used, capable of drawing graphs of points, bar, line, curves, 2D or 3D among others.

The overall organization of the platform will be discussed afterwards.

2.1 Conceptual Model

The PAE's interface uses basic elements and data structures developed in Java, derived from the graphic model resulting from the user-machine relationship. Thus, the user intuitively feeds the components of the model to be analyzed, generating all the preprocessing parameters, and from the graphical interface, an input file is created. Therefore, the interface enables the preprocessing file which consequently ensures the analysis and model solution and can be consumed for any solver in finite elements which reads the file generated. Currently there is a solver already developed in FORTRAN that reads the data pattern generated by the GUI.

2.2 Structure of the Graphical Interface

The principle used for the structuring of the application was the identification of classes and

objects, components of the problematic domain and the establishment of their relations, within that governed by the object-oriented paradigm. A basic diagram of the graphical interface is shown in Fig.1.

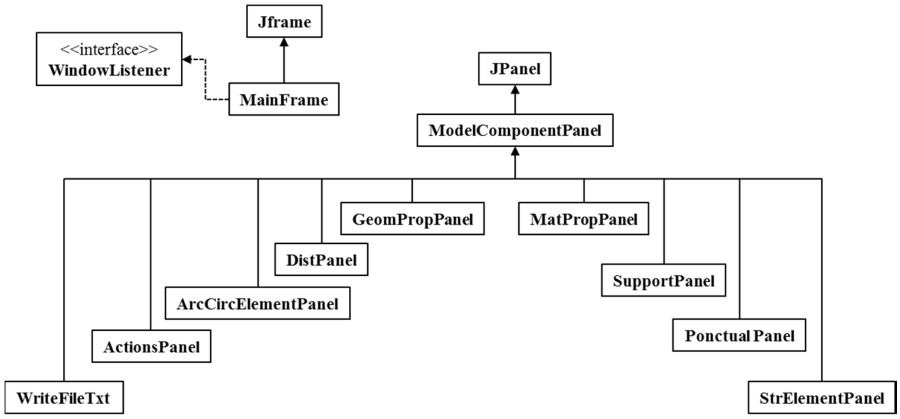

Figure 1. Class diagram of the graphical interface

- MainFrame - Main window that shows all the paths and functionalities of the system.
- GeomPropPanel - Panel for insertion of the geometric properties of the elements.
- MatPropPanel - Panel for insertion of the material properties of the elements.
- SupportPanel - Panel that enables the insertion of model supports at nodes.
- DistPanel - Panel referring to the definitions of distributed loads applied to elements.
- PonctualPanel - Panel referring to the definitions of concentrated punctual loads applied to nodes.
- ArcCircElementPanel - Panel where the informations of the circular arc are inserted and its drawing is generated from them.
- StrElementPanel - Panel where the informations from the straight elements are inserted and its drawing is generated from them.
- ActionsPanel - Panel responsible for entering the characteristics of loads (distributed loads and/or point loads).
- WriteFileTxt - Class responsible for the generation of the input in .txt format.

All data treated in these classes are entered by the user with the exception of the WriteFileTxt class which represents the generation of the model with all its properties already structured from the drawing.

3 Results

All these concepts applied during the development of PAE enabled the result of a didactic and efficient graphical interface, aiming future modifications and improvements. Currently, this application performs models composed of straight and curved axis elements. In order to demonstrate its use, the following Fig.2 and Fig.3 illustrate how the relationship with the user was conceived and also how the graphical representation is generated.

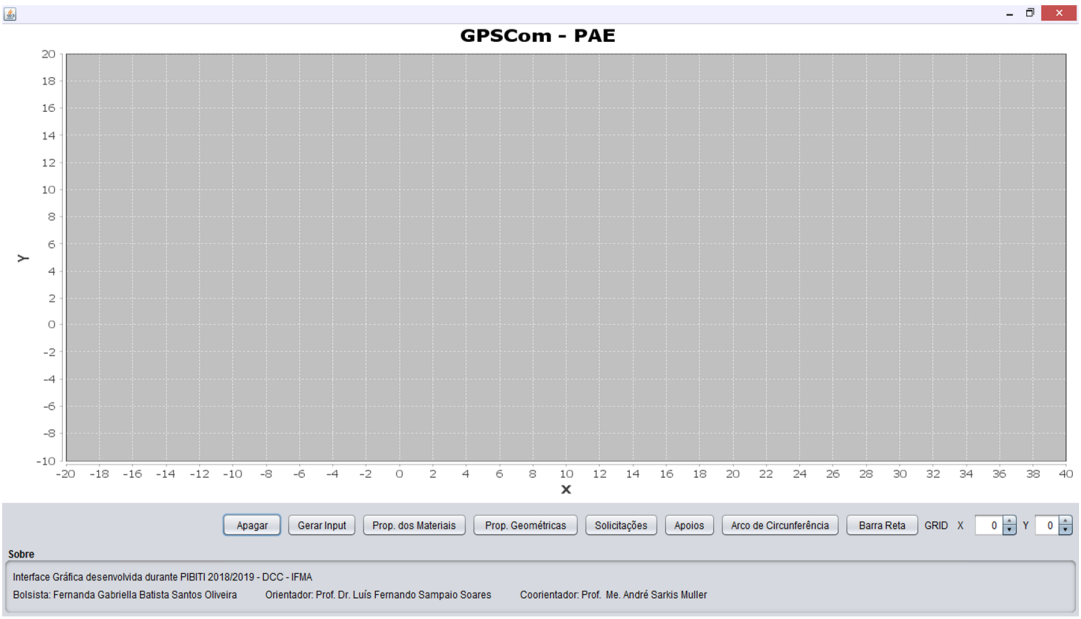

Figure 2. Main window

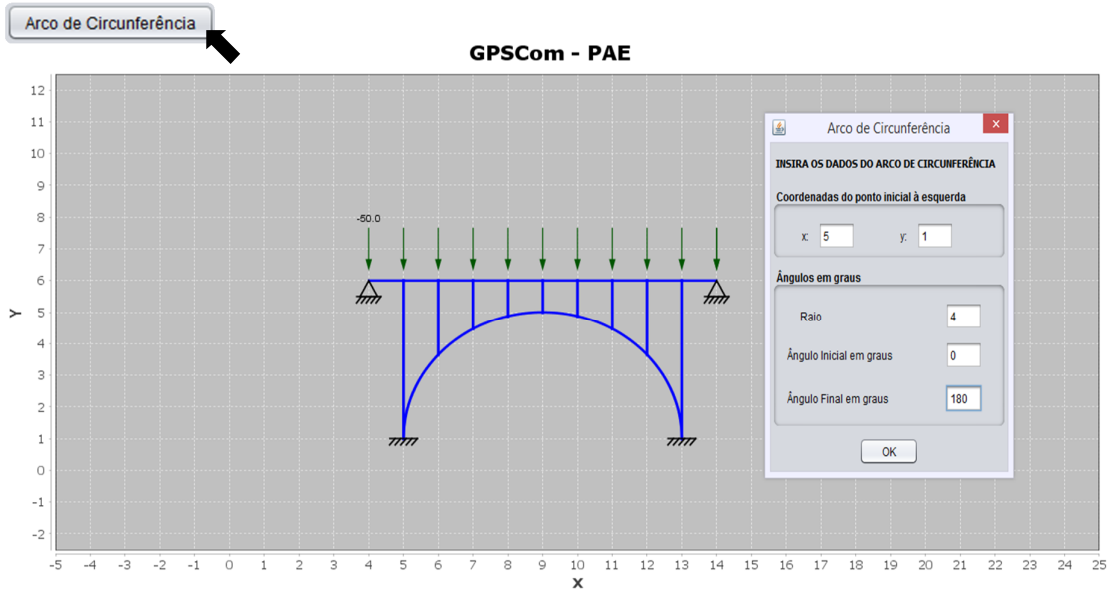

Figure 3. Data entry of the circular arc and its graphic representation with straight bar elements

One of the purposes of the interface is the generation of the input format. For its generation, a button on the main frame (Fig.4) is responsible for triggering through methods developed in the system, the creation of the desired input according to the adopted format (ENTRADAP.txt, for example) illustrated in Fig.5, describing the structure drawn in a single file. The elements and their properties are organized in data structures that make up a single structural model, which contains all the information necessary to generate the input, sufficient to characterize it and allows its resolution.

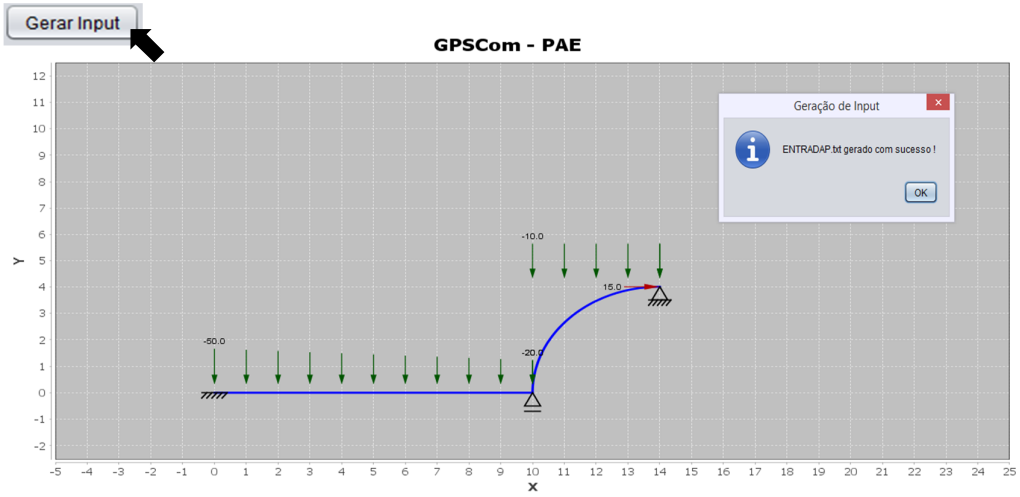

Figure 4. Input Generation

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****---------------------------------- ARQUIVO DE ENTRADA DE DADOS ----------------------------------****
****---------------------------- PROGRAMA DE ANÁLISE ESTRUTURAL (PAE) ------------------------------****

|Nº NOS| & |Nº ELEMENTOS| DA ESTRUTURA EM ANALISE

   3            2

 |NO|    |COORDENADA X|  |COORDENADA Y|   |Fx|      |Fy|     |MOMENTO Z|     |VINCULACAO X|     |VINCULACAO Y|     |GIRO Z|

  1         0.0             0.0          0.0       0.0         0.0              1               1               1
  2         10.0            0.0          0.0       0.0         0.0              0               1               0
  3         14.0            4.0          15.0      0.0         0.0              1               1               0

|ELEMENTO|    |NO INICIAL (i)|  |NO FINAL(j)|  |RAIO|  |ALFAi|  |ALFAj|  |PSI|  |E|     |G|     |Iz|     |S|     |Qxi|    |Qxj|    |Qyi|    |Qyj|

    1             1               2           0.0     0.0     0.0     1.0   210.0   100.0   12.0    4.0     0.0     0.0     -50.0   -20.0
    2             2               3           4.0     0.0     90.0    1.0   210.0   100.0   12.0    4.0     0.0     0.0     -10.0   -10.0
```

Figure 5. Example of input data (ENTRADAP.txt)

4 Conclusion

Therefore, this graphical interface enables the analysis of curved-axis elements, such as circular arcs in addition to the linear analysis of bars based structures (beams, frames). In light of the above, we seek to continue the development of the interface with the addition of new elements aligned with those already created, always emphasizing the efficiency of processing and user-machine relationship, with the aim to provide a simple and intuitive environment for the launch of models for structural analysis.

Acknowledgements

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References

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[3] C. S.Horstmann and G.Cornell. *Core Java 2: Fundamentos*. São Paulo: Makron Books, 2001.