PYTEXLIB – OPEN SOURCE PYTHON LIBRARY FOR SCRIPTING TEXTILE STRUCTURES

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ABSTRACT

This work presents a small, minimalistic, pure Python based open source library, which was designed to simplify the parametric creation of textile structures. The library comes as result of long years of teaching modelling of textiles at master and PhD level, where the difficulties with all existing packages and the learning outcomes from such one course were considered. The idea of the library is that the students learn at the same time first steps of programming Python using small library, it is running on any operation system and from other point of view, the user is able to concentrate on the textile architecture, not getting lost in the coding style, data structures etc. PyTexLib is used since 4 years successful in the education at TU Dresden and in WE-TEAM program and is available as open source at GitHub.

KEYWORDS

Modelling; Textile structures; Library; Open source; 3D modelling; Python.

INTRODUCTION

There are many professional CAD packages for automatic creation of textile structures, which cover single type or groups of textiles. For weaving – there are more than 20 CAD packages [1], which creates photorealistic simulation of the fabrics and can export machine data, but only few of these can provide real 3D data for FEM simulation or other analysis of the structures (as pore size, CFD, etc.). Only WiseTex provides mechanical computations of the minimal potential energy of the yarns in order to provide mechanically correct geometry [2]. For knitted structures the CAD packages are very limited. Both leading machine producers Stoll and Shima Seiki have excellent photorealistic representations of the weft knitted structures, but 3D view can be generated only by the software of Shima Seiki, but until now is no reported any export option for more simulations. Several types of weft knitted structures and warp knitted structures and as well braided can be generated in 3D and exported to various format by the software of company TexMind (https://texmind.com/). These are convenient for work and export, but are as well limited to the programmed structures inside. Only the software TexGen [3] is open source, which allow scripting and creation of custom structures. Actually, there are few shortcomings working with TexGen which have prevented the authors of using it in the research and caused the creation of a new library. Once problem is, that TexGen works fine with unit cells, but is (or at least during the last year was) not capable to operate fast with large structures with more yarns and filaments (like knitted). The second problem is, that it is GPL Licensed and any advances of the software have to remain GPL License, which is potential problem in case of performing applied research together with industrial partners. Another, third problem is, that although TexGen can be compiled on MACOS and Linux, it does not provide direct installation files for such systems, which was causing troubles during the education of students in a classroom.

Based on this analysis and experience the authors decided in the past to develop small (minimalistic), open access, pure Python based library for scripting textile structures, which can be effiziently used in the education and for creation of complex or custom structures, which are not covered in the packages of TexMind or else. This was already successful applied in one PhD thesis [4] [5]. In the education of the WE-TEAM master students (https://we-team.education/) during the course of Computation Sciences and Engineering Principles for Textiles and during the lectures at TU Dresden.

LIBRARY STRUCTURE

Python was chosen as language, because it is currently wide used, free, open source and available on all systems. The library is hosted on GitHub

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(https://github.com/virtualtextiles/pytexlib) and a MIT License was chosen, so that any person is free to use it and apply in any projects – public and commercial, without any limitations.

The goal is to have simple library for creating textile structures, where the develop concentrates on the textile and not on the programming structures in Python. For this several classes were developed:

The ***fibre*** class (file fiberlib.py) is the basic class in the library in the same way as the fibers are the basic elements of all fiber based structures. Each fiber is at the current state with circular cross section and has defined fibre diameter d, colour with the red, green and blue values and has list of coordinates of the fibre axis. The generation of fibre with two points of the axis is as simple as follows:

```
fi=fiber()
fi.diameter=0.2
fi.setcolour(123,23,230)
fi.append_point(1.0,2,3)
fi.append_point(12.0,2,3)
```

The first line constructs new fiber "*fi*". The second and third lines specify its diameter and color. After that the developer has to add points with their *x*, *y*, *z*, coordinates and can use not only numbers, but as well parameters with all possible options of the Python syntax.

Before one fibre is assigned to a yarn (or other structure), this has to be created by the constructor

```
ya=yarn()
```

In this case as yarn can be created as well non-woven structure, the meaning of one yarn is that it represents ***a group of fibers***.

Adding the fiber is then one simple line:

```
ya.add_fiber(fi)
```

Analogously, the yarn has to be assigned into textile structure

```
t=textile()
```

and added there

```
t.add_yarn(ya)
```

With these steps, the textile structure with one yarn and one fiber is ready and can be saved into CSV file

```
t.write_file("mysample.csv")
```

so that this can be visualized by the TexMind Textile Viewer (free software), used as wellin the book Warp Knitting Fabrics Construction [6] and can apply all types of exports (for instance LS-Dyna, Abaqus, Ansys, gltf, STL, x3d etc, Wisetex, Texgen script) in the standard TexMind packages.

The structure can be visualized by the simple command:

```
t.plot()
```

DISCUSSION POINTS WITH OPEN ISSUES

The current library does not contain class for "groups of yarns" which is the case for all ply yarns. Actually two- and three-ply yarns are used very often and even more than the single ply yarns. Additionally, contrary to the structures in the software and the data formats of TexMind for instance, there is no implemented class for groups of (ply) yarns. Such grouping helps significantly for selection and visualization of warp or weft yarns only at woven structures, or different systems of multilayer woven structures (upper layer, bottom layer, connecting warp etc.). Such grouping is efficient in the warp knitting, too, where each guide bar represents separated group of yarns. Both the ply yarns and group of yarns represents two levels of lists of existing objects. During the creation of the library the developers decided initially to skip these levels, in order to simplify the coding. Because in the case of structure with single yarn, it has to be added into ply yarn with one yarn, and this ply yarn has to b added to a group of yarns, which could contain only one yarn, too, if all levels have to be represented. One alternative option for sorting, which is less efficient but more convenient for beginners is the adding of attributes like "Ply Yarn ID" or "Yarn Group ID", which can be used internally for searching and sorting and visualization of the objects from one group without the need of implementation of two more levels of grouping.

Another aspect is the 3D visualization of the structures. At the current time one option is the export of the geometry as text file with specific format (CSV) and visualization with the free TexMind Viewer. This visualization is better than the using only the 3D axis. The integration of the 3D visualization of the library is possible but had some disadvantages during the teaching. One very powerful 3D library is vtk, actually used in TexMind Viewer. Vtk can be used in Python, too, but requires C++ compiler during the installation. This requires often administrative rights and was trouble for the installation in classroom environments. A very nice and simpler to use, compared to vtk library

Figure 1. Objects in PyTexLib. The red objects are not implemented for simplicity at the current time

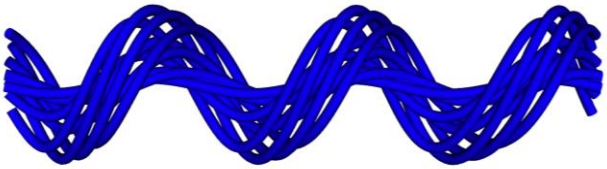

Figure 2. Created yarn with spiral effects within PyTexLib.

are pyVista, open3D, or Vedo. They actually all present python warping of vtk, and this brings the same troubles as vtk itself. The authors are looking at the current time for suitable, pure python based 3D library for visualization, which has as less dependencies as possible and works on multiple platform without needs of administrative rights at this point.

RESULTS

Figure 2 presents one example of a multifilament yarn created with PyTexLib. This is a yarn with spiral effects, where some core filaments are placed almost straight in the middle of the structure and the remaining filaments are around these. The generation is done within 14 lines of code for this structure, (not considering the PyTexLib and the visualization libraries itself).

CONCLUSIONS

The new open source python library PyTexLib allows quick start in creating 3D geometries of textile structures. It requires only basic understanding of programming and elementary syntax in order to implement parametric geometric models into 3D visualizations. It can be a good tool for quick start in the 3D modelling of textile structures, especially for such structures, which are not covered in the available CAD packages.

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