Development of Shapefile Converter for Simulation of Wind & Thermal Effects of Buildings & Trees in Built Environment with Terrain Effects

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Abstract

Shapefile (*.shp) is a popular geospatial format used in geographic information system (GIS) software. This format uses points, lines, and polygons to represent urban textures such as buildings, trees, water bodies, and roads. It is a publicly available format, and all the existing GIS software can handle the information without any issue. This file format is popular in urban planning, and shapefiles for many cities around the world are freely available for download. However, the topographical information of the represented shapes is not available a part of the format specification. Shapefiles are incompatible for three-dimensional computational fluid dynamics (CFD) simulations of the urban areas.

Few open-source shapefiles to three-dimensional model converters are available in the literature to deal mostly with resolving the buildings. Buildings are usually represented as polygons and converting them to three-dimensional models do not require additional effort. Trees in the shapefiles usually are represented using three attributes: (i) location, (ii) leaf area index and (iii) girth. This information is not enough to construct a model of the tree. The existing shapefile converters do not handle tree conversion.

This study develops a three-step automated framework for handling shapefiles of buildings and trees in CFD software. In the first step, a Python code is developed for converting the shapefiles to stereolithography (STL) format for the buildings. The tree information is stored in a comma-separated value (CSV) file. In the second step, a user-provided three-dimensional tree model and the CSV file is used to scale and translate the three-dimensional tree model to their corresponding location. In the final step, additional preprocessing is performed to convert the tree information into a porous media model (popular model for representing trees in CFD codes). This porous media model and the building STL files can be used for simulation using CFD software. Additionally, the mesh used for the simulations organically incorporates terrain information for greater modelling accuracy. Preliminary results using OpenFOAM and PALM-LES are shown to illustrate the capabilities of the framework. A graphical user interface is also under-development to make it easier to automate the preprocessing framework. The development of a QGIS plugin of the framework is also under development.

Keywords: GIS, Shapefile, CFD, STL, Trees, Built Environment