OTSunWebApp: Manual of FreeCAD file

Ramón Pujol-Nadal[1] and Gabriel Cardona Juanals[2]

[1]Dept. d'Enginyeria Industrial i Construcció, Universitat de les Illes Balears
[2]Dept. de Ciències Matemàtiques i Informàtica, Universitat de les Illes Balears

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This manual outlines the key features required to build a FreeCAD project for optical simulation.

The optical system to be analyzed must be modeled in a FreeCAD [1] file, where the user designs the solids and surfaces that build the mechanical model, and assigns optical properties to them.

Being FreeCAD a Computer Aided Design (CAD) software, the geometrical properties of the elements that form the system are inherently encoded in the file. Some other properties of these elements, as their material or how they can move, are encoded in their *Label*, which is a string that the user can associate to any object in a FreeCAD file and identifies it. See the left panel in Fig. 1, where the elements that build the mechanical model are listed.

Namely, in order to be simulated by OTSun, an object must have a label of one of the three following forms:

1. `name(material)`
2. `name(material,axis,normal[,target])`
3. `name(material,axis1,axis2,normal[,target])`

The parameter `name` is simply an identifier which the user can set arbitrarily, and is only used for logging purposes.

The first parameter inside parenthesis, `material`, is compulsory (i.e., if it is not given, then the object will be discarded internally and the light rays will not interact with it) and determines which material it is made of, and must match the identifier of an optical material as described in the manual available in `https://otsun-uib.github.io/manuals/materials.pdf`.

The other (optional) parameters determine if the object under consideration can move in order to track the sun, and the different forms correspond to different possible movements.

In the second form above, `axis` is the label of a FreeCAD edge that is the axis of rotation of the object, which hence admits one-dimensional movement. The parameter `normal` is the label of the FreeCAD edge whose direction is the *principal vector* of the optical element

(i.e. the direction that best approaches the normal of the mobile element). The parameter `target` is optional. In case that it is given, the object will be oriented (by means of a suitable rotation around its axis) so that light rays are focused (as much as possible, since a full focus would require rotations around two independent axis) in the object with the given label, which must be a point object. If no target is given, the rotation will be computed so that the object returns the rays (again, as much as possible) to the light source. These movements allow for the simulation of one-dimensional trackers: if `target` is given, it is suitable for solar trackers as in Parabolic Thought Collectors (PTC) devices, otherwise it is for mirror trackers of Linear Fresnel Reflectors (LFR). See [2], and its supplementary data, for an optical simulation of a LFR.

In the third form, the object is given the ability to make two-dimensional movements, by means of two independent rotations around the axis determined by `axis1` and `axis2`. The other parameters that must be specified are the same as in the previous forms. In this case, the movement is obtained by first applying a rotation around the axis whose label is `axis1` (which is assumed to be a vertical vector, parallel to the Z-axis) and then a rotation around the one with label `axis2` (which is assumed to be an horizontal vector, orthogonal to the Z-axis). With this movement, it allows for the simulation of two-dimensional solar trackers, if `target` is omitted, or two-dimensional heliostat trackers in Solar Power Towers (SPT), if `target` is given.

Fig. 1 shows a visualization of a SPT plant drawn in FreeCAD. The different objects are listed in the panel on the left and are shown together with their respective labels. As mentioned above, the different parameters in parentheses indicate the necessary information to assign materials, and to perform sun tracking movements. Fig. 2 shows the objects and labels for one single heliostat from the SPT sketched in Fig. 1.

References

[1] J. Riegel, W. Mayer, Y. van Havre, FreeCAD (2001).
URL `http://www.freecadweb.org`

[2] G. Cardona, R. Pujol-Nadal, OTSun, a python package for the optical analysis of solar-thermal collectors and photovoltaic cells with arbitrary geometry, PLOS ONE 15 (10) (2020) e0240735. `doi:10.1371/journal.pone.0240735`.
URL `https://dx.plos.org/10.1371/journal.pone.0240735`

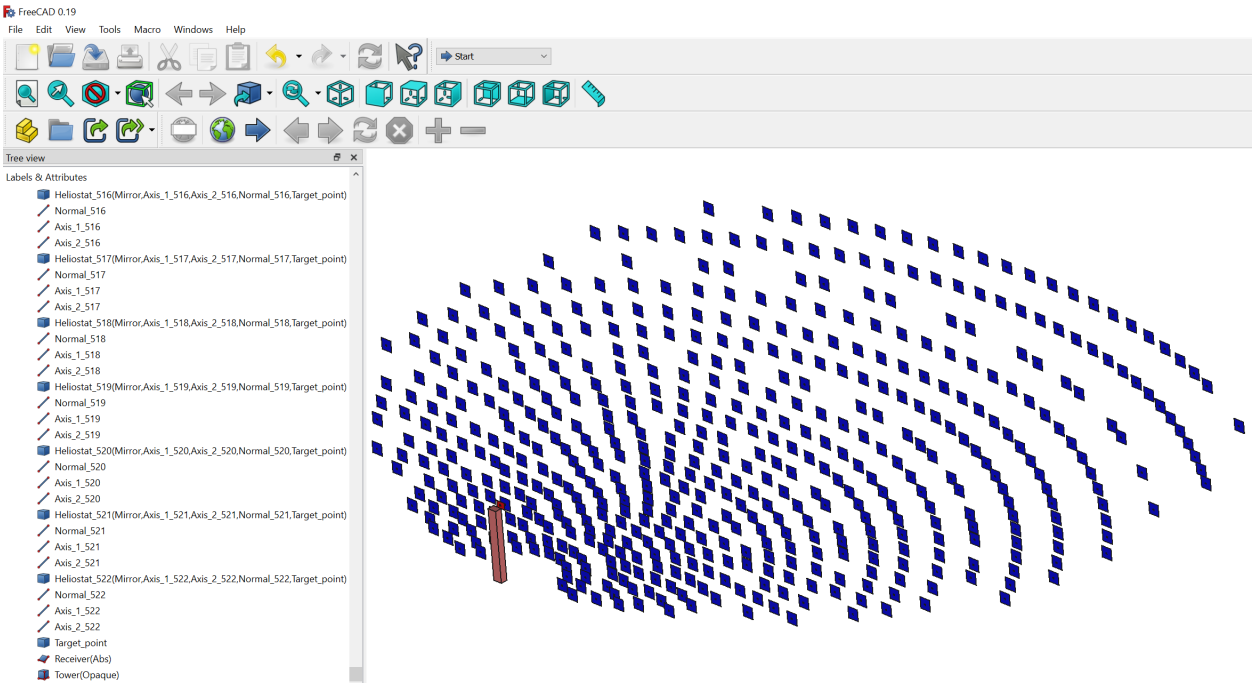

Figure 1: Screenshot of a SPT modeled using FreeCAD. The objects that form the scene are listed in the left pane along with their labels, which include inside parenthesis the parameters that define their optical and mechanical tracking properties.

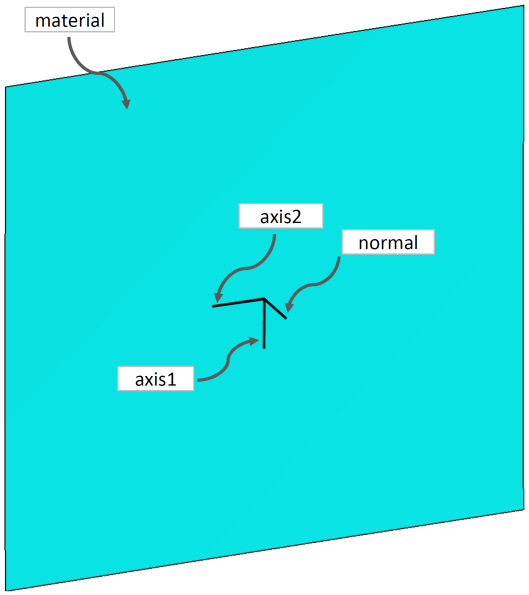

Figure 2: Objects (and their labels) that describe the movement of one single heliostat from Fig. 1 and whose label must be typed as `name(material,axis1,axis2,normal,target)`.