To Make SOLWEIG User-Friendly – A climate design tool

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The aim of this work is to build an architecture around "SOLWEIG – a climate model made in MATLAB" [1,3], which makes it extensible and user-friendly. This is a joint project between the Software Engineering Group at Chalmers University of Technology and Urban Climate Group at University of Gothenburg. SOLWEIG is a radiation model that can make climate estimations (such as sunshine durations, shadow patterns and daily shading) and analyse the complex interaction between urban design and the thermal environment. It was developed by the Urban Climate Group, Department of Earth Sciences, University of Gothenburg, Sweden.

Background: SOLWEIG comes from the acronym SOlar and LongWave Environmental Irradiance Geometry. It is a software solution that estimates spatial variations of three-dimensional radiation fluxes and mean radiant temperature (T_{mrt}) in complex urban settings. The T_{mrt} is one of the most important meteorological factors that govern human energy balance and the thermal comfort of man outdoors. It can be defined as: "The sum of all short and long wave radiation fluxes (both direct and reflected), to which the human body is exposed" [1]. The SOLWEIG model bases its origins from a sustainable urban design perspective, with the aim of determining how the radiation fluxes and the T_{mrt} can affect the health and wellbeing of the humans in a concrete urban setting along a concrete day. The model is targeted to the researchers of the subject as well as architects and urban planners.

SOLWEIG bases its calculations on a map, which represents spatial variations of urban geometry, called DEM (Digital Elevation Model) [2]. The T_{mrt} is derived from this data plus some other inputs, "such as direct, diffuse and global shortwave radiation, air temperature, relative humidity and geographical information (latitude, longitude and elevation)" [3]. In order to show the results, the model generates three different types of outputs: **Maps, Diagrams, and Data files. Maps:** a set of twenty-four figures that show the spatial variations of the T_{mrt} for each hour of a concrete day plus one more that contains the average of all this information. **Diagrams:** three graphical diagrams that show the spatial variations of the T_{mrt} and both the short and long wave radiation fluxes in a concrete point of the DEM. **Data files:** a text file of all modelled parameters from one specified location within the model domain which are stored in the user's computer.

Aims: The SOLWEIG model has given impressive results [1]. However, it is difficult to use by anyone else than the Urban Climate Group in Gothenburg, since the model is using command-line interface. In addition to a difficult user interface, SOLWEIG lacks an explicitly stated process. Furthermore, any mistakes made on the interface when typing or loading a file forces the user to restart the whole model again. In the same way, the user has to restart (and thus retype) the model every time some new results are needed to be obtained.

We wanted to make a tool which can be shared with researchers outside the Gothenburg Urban Climate Group, architects and urban planners. In addition, we wanted the tool to be available without the need for buying a license. This gave some extra constraints in building our tool. For the development of the tool, three requirements have been taken as targets: user friendliness, extensibility, and usability.

Method: The main method has been the meetings between the four authors from which the targets of the graphical interface were obtained. These targets have been: user-friendly interface, extensibility of the code, and usability of the whole tool. They have been solved by developing and analysing some technical documents that have defined the structure (both the external and the internal one) of the interface. It is worth to mention that a Model-View-Controller architecture has been applied, since it covers the extensibility target and facilitates the achievement of the other two ones. In order to measure the fulfilment of user friendliness and usability, the tool was evaluated by seventeen subjects who were both familiar and unfamiliar with SOLWEIG.

Results: We have implemented the tool using Java [5] because of the powerful graphical library called Swing that contains the necessary features to get a very user-friendly interface. In addition, it is freeware and only requires a virtual machine installed in the computer of the end user in order to be able to execute any Java applications. Regarding the connection with the SOLWEIG model (which is written in MATLAB), the tools MATLAB Compiler and MATLAB Builder JA [4] have been used to obtain a Java version of the model, so that the graphical interface can execute the MATLAB functions by making use of a MATLAB runtime engine called MATLAB Compiler Runtime. This application can be deployed royalty-free along with the graphical interface. Therefore in this way the graphical interface can take advantage of MATLAB matrices processing and plots of DEMs in order to get the fastest and efficient simulation of the model; while, regarding the distribution of the application, it can be shared with researchers, architects and urban planners without the need of buying a license.

Our choice of framework has permitted us to make a powerful user interface which supports the user in obtaining results from SOLWEIG. The process has been made explicit, the user knows all the time what to do next. In addition, default values have been given for several of the arguments. If the user wants to execute SOLWEIG repeatedly with new data, they do not need to start from the beginning. Of course, one needs to start from the beginning if a new DEM is required, since the whole process depends on the DEM. The results from our seventeen subjects can be considered as satisfactory, as most of the questions answered by the testers have had a positive feedback. This tool is a crucial step to allow sharing the model with the users, such as architects and urban planners, in a visual and friendly way and without involving any costs, as it is completely free. This project was a success due to the close collaboration between the Software Engineering Group and Urban Climate Group. The SOLWEIG model is used by different research groups for example in China, Italy, UK and Germany.

Conclusion and Future Work: The challenge of this project was to introduce software engineering practices into the domain of urban climate. As a software engineering department we know how to build system requiring only a few people over a period of a year or two. The type of collaboration we have done in this project can benefit non-IT research groups such as the Urban Climate Group to obtain complete tools to support their work and other groups which would like to use the tool. There should be better support for this type of cross-discipline projects in the academia. In a couple of weeks we will upgrade to version 2.0 which will include a vegetation scheme. We will also make it more user friendly so that the user can choose different kind of outputs (e.g. .jpg).

References:

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